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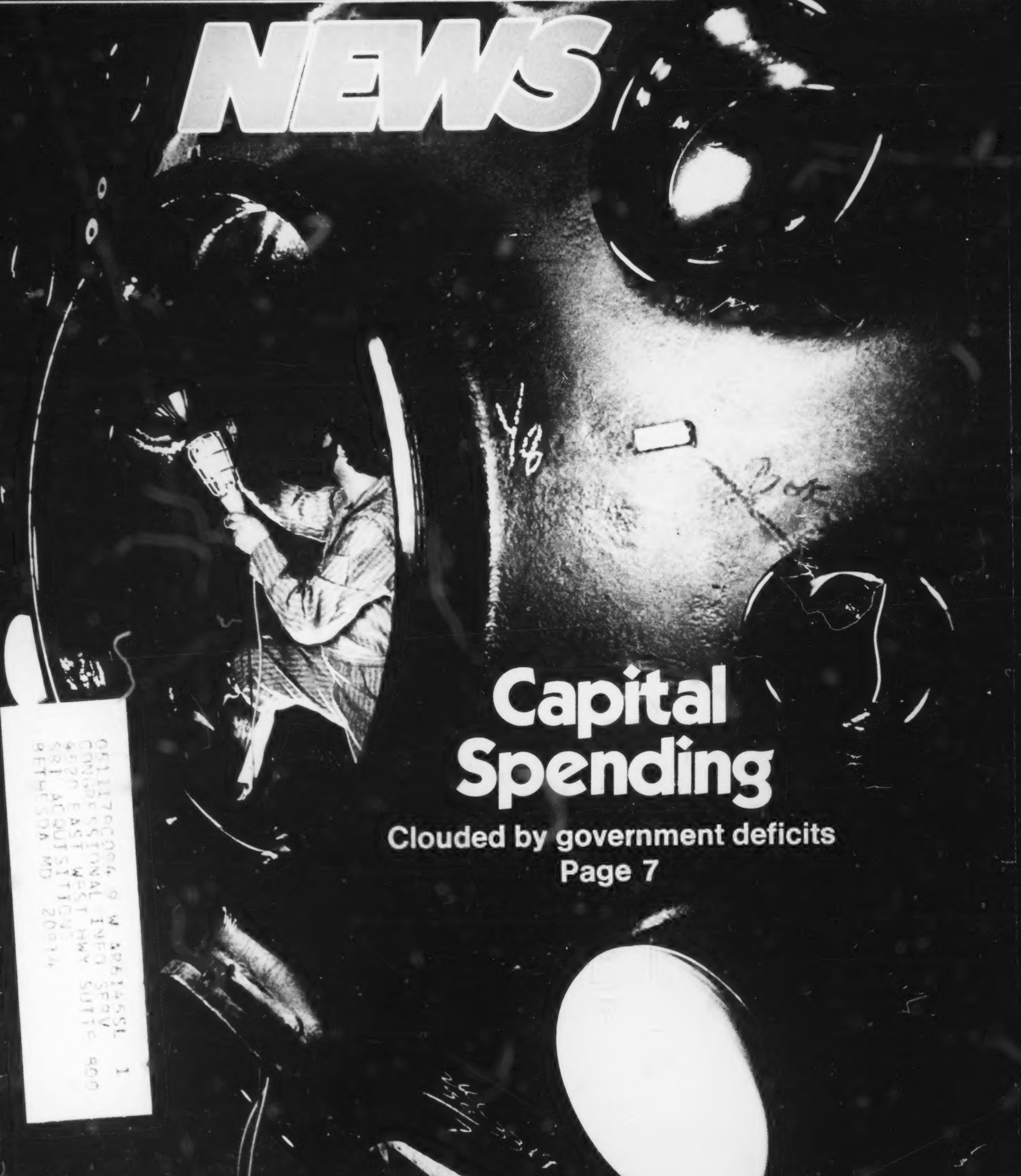
CHEMICAL & ENGINEERING NEWS



Capital Spending

Clouded by government deficits
Page 7

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Cover: Pressure vessel—targeted for new plant—is inspected at Pfaudler unit of Standard Oil (Ohio) in Rochester, N.Y., by Charles Calaci. Photo by Steve Kahn

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Chemical industry capital spending for plant and equipment may be hurt by the federal deficit, through high interest rates, tight credit. Page 7

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Federal Deficit May Hurt Captial Spending

Massive government borrowing may lead to higher interest rates, slower growth, making capital formation hard for chemical industry

William J. Storck, C&EN New York

It may be sooner than most corporate planners think to start considering the next big wave of investment in plants and equipment in the U.S. chemical industry. The most important question may be whether, financially, any new wave can happen.

True, the recession left a gaping margin of unused plant capacity, and the universal assumption has been that a long break would follow in capital spending. But chemical economists are beginning to worry just the same. Although business conditions have improved dramatically and a good 1984 looks virtually assured, economists fret that just when new investment will be needed late in the year or in 1985, an ominous outside factor could shut it off—the capital-hungry U.S. federal budget, which promises a string of huge deficits sopping up much or most of the country's available credit. Such competition could be stifling for chemical and other manufacturing investment.

Currently, demand for chemicals is going so well that capacity utilization for chemicals and allied products, according to the government's survey, has moved up to 71% on a seasonally adjusted basis, compared with 65% at the beginning of the year and a 1982 low of about 64%.

C&EN's own survey of capacity utilization shows basic chemical plants operating at about 68% of nameplate capacity in the third quarter of this year and at about 76% of effective capacity (C&EN, Oct. 10, page 6). Production increased at the same time that some capacity was still being closed.

However, with capacity utilization moving up, it will not be long before chemical companies must begin to consider new capacity additions. And herein lies a problem,

NEWS ANALYSIS

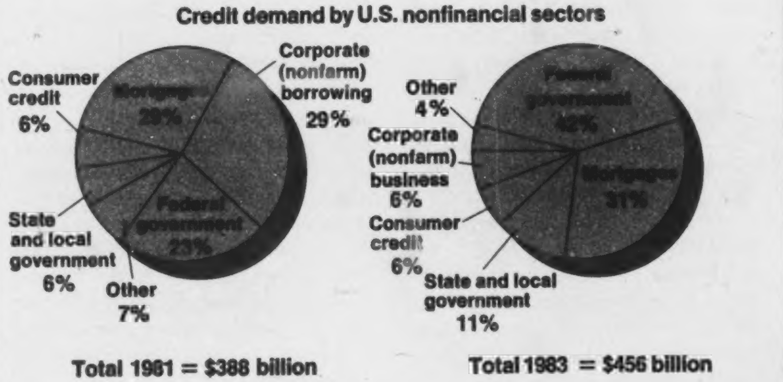
according to many economists. They feel that just at the time that companies must begin a new round of capital spending, which has been declining in recent years, the federal budget deficit will make the cost of capital too expensive to justify new plants. This will be especially true in basic chemicals, based on the possible return on investment that the companies can get out of those plants.

Since there is only so much credit available, the massive government deficits will take much of that credit. As one corporate economist says, "When you are competing against the government, there is no competition." The government, which can afford to pay any interest rate, will diminish the credit pool enough that interest rates will be bound to rise, making it much more expensive for corporations to borrow.

An example of just how much the government is taking was published recently by Morgan Guaranty Trust Co. The New York City-based bank says that in 1981, the federal government's share of credit demand was about 23%. This year, however, the federal government's share of domestic nonfinancial credit demand will rise to about 42%—almost a doubling in just two years.

Thus, the laws of supply and demand come into play, and as demand for the available credit increases, so will interest rates.

The problem is not immediate in that companies probably will not need to borrow much in 1984. James F. Smith, chief economist for Union



Federal share of credit demand almost double since 1981

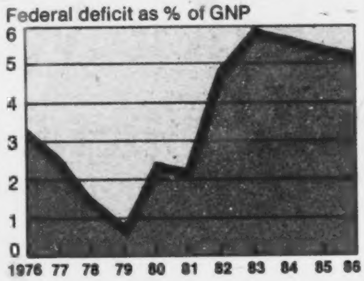
Credit demand by U.S. nonfinancial sectors

Source: Morgan Guaranty Trust Co.

Carbide, says that federal deficits will have little or no effect on capital formation until mid-1985 when the need for new plants becomes critical. Before that, he says, chemical companies will be able to finance capital improvements, which will be mainly in the form of new equipment or plant streamlining, out of internal cash flow. Smith says that the only time that companies will require larger financing in the next year and a half to two years is when they want to get into new lines of business or to adopt new technologies.

Nicholas Filippello, Monsanto's chief economist, says that "the microdecision to build a plant is affected only marginally by interest rates." Companies, he says, measure the investment against the cost of capital, which includes both debt and equity. They then aim for a return on investment that is higher than that cost of capital. However, since the interest rates are figured into this cost, the higher price that companies have to pay for debt does increase the cost somewhat. The problem, says Filippello, will be in the basic chemical area, where the returns are naturally lower.

Deficits as per cent of GNP will run twice historic rates



Sources: Bureau of Economic Analysis, Conference Board, C&EN estimates

Thus, some firms, for whatever reason, may have taken the right way when they decided to switch their emphasis to the higher-value-added specialty chemical products since these will be more likely to give returns higher than the cost of capital to build new plants.

In fiscal 1982, the federal deficit was about $147 billion. In fiscal 1983 it was $195 billion, according to the latest government figures, and there it will stay for some time. Defense spending plus entitlements plus interest payments of the federal debt adds up to about 80% of the federal budget. The government's own estimates are that these will rise to 88% in just a few years. Thus, the government is projecting deficits in the $190 billion range for the next three years.

This means that the federal deficit will amount to about 6% of the U.S. gross national product in 1983. In other words, the deficit robs about 6% of GNP. Although this percentage will trend downward for the next few years, if the deficit remains at about its current level and GNP rises, it still will be above 5% of GNP in 1986, according to the Conference Board, a New York City-based business group. This is more than twice what the percentage was just three years ago in 1980 when it was 2.3% and about three times the historic level.

Monsanto's Filippello, who is also president of the National Association of Business Economists, says that the ratio of deficit to GNP is not the whole story. He points out that in many other countries this percentage is high, but that these other countries have a high rate of savings that will finance the deficit. This, he says, is not true in the U.S., where the federal deficit takes up to 75 to 80% of savings. Some economists say that when off-budget items are added, the deficit exceeds the available savings.

This means that the deficit must be financed by capital inflows—monies coming into the U.S. from other parts of the world—which keeps interest rates high, makes the dollar stronger than it should be against foreign currencies, and draws capital away from other parts of the world.

Carbide's Smith feels that as the recovery progresses, government revenues increase, thus cutting the projected future deficits somewhat. In fact, he is worried that if the deficit goes down, Congress will not focus on the problem and the actions that need to be taken. "Before you know it we could have a $300 billion deficit," Smith says.

In a talk to the Conference Board's Business Outlook Conference in New York City earlier this fall, Du Pont's vice president of finance, William E. Buxbaum, said that there are three reasons for the higher cost of money compared to historical norms. These are the deregulation

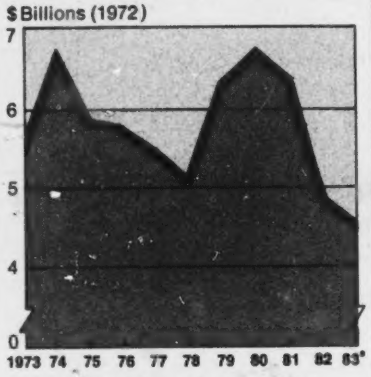
A dissenter downplays deficits' damage

Not everyone agrees that deficits are, in themselves, bad for the economy and for investment. One of the dissenters is Albert M. Wojnilower, managing director and chief economist for First Boston Corp., headquartered in New York City. At a meeting of economists discussing the "Economics of Large Government Deficits" held at Melvin Village, N.H., last month, Wojnilower said that placing the blame on the budget deficit "is a cop-out."

Wojnilower told the meeting, which was arranged by the Boston Federal Reserve Bank, "Government deficits may well promote rather than deter investment." According to the economist, the government is likely to borrow to finance its own investment outlays and to finance grants-in-aid earmarked for state and local investment outlays. It borrows to finance investment tax credits, accelerated depreciation allowances, and other subsidies that support private investment. Wojnilower then asks the question, "Would narrowing the budget deficit by the abolition of these tax incentives promote private capital spending?"

Wojnilower says that in most cases more borrowing and more spending raise the level of nominal income, investment, and saving. If the extra debt, he says, is private debt, private saving will tend to expand because someone has to hold the extra securities. If the extra securities are government debt, private saving again will be higher. However, then national saving as it is measured cannot be higher because the larger government deficit is defined as dissaving. He allows that the result will be inflation, but, Wojnilower says, as long as prices inflate faster than costs, profits and investment will thrive.

Capital appropriations for chemicals continue to fall



a C&EN estimate. Source: Conference Board

of financial institutions, a higher risk factor, and concern about huge projected structural budget deficits. He says that the risk factor and concern about budget deficits are manifestations of the same problem—inflation and interest rate expectations over the medium and longer term.

In fact, economists are worried about more than rising interest rates. They fear that the large federal deficit could cause a number of other problems including inflation and a slowing in the economy, or a combination of the three. And, they say, if the deficits slow the economy in 1985, largely because of the inability to create capital, the situation would feed on itself. As the economy would slow down, the government's revenues would decline, creating even larger deficits.

Filippello says that four things could be done to cut the deficit. The government could cut growth in outlays with a net shift back toward the private sector. However, this is unlikely in an election year. Another move that would be unpopular, hence unlikely, in an election year would be an increase in taxes. However, this would not balance the budget because an increase in taxes means less money in the economy. The government could borrow money from the private sector, an action that would put a limit on spending for housing and capital goods and could renew the recession. Or the Federal Reserve could expand the money supply. In this regard, most economists agree that it is possible for the U.S. to inflate itself out of deficit problems as it did in the late 1970s.

Filippello adds that taxes may be raised and outlays may be cut, but not until after the election. The key question then is whether this is soon enough. Most projections see the crunch hitting in 1985. If this is true, just at the time that the chemical industry will need to begin to build new plants, the scramble for credit will take place. Or in the worst case, if the deficit causes another recession, the question becomes: Will cutting the budget in late 1984 or early 1985 stop a slowdown that already may be built in for that year? □

Engineering plastics head for new growth

After a frustrating half-decade, one of the high-premium parts of the U.S. plastics industry may be about to break loose for vigorous new growth. Engineering thermoplastics—high-property materials used in diverse structural applications from business machine housings to auto exteriors—could jump about half in U.S. use from 1982 through 1987, concludes consultants Business Communications Co. of Stamford, Conn., in a new report. That would produce a 1 billion lb annual market.

This is a welcome spurt for engineering thermoplastics, which have been in the 650 million to 850 million lb range since 1977. Producers of these materials were not accustomed to standing still, having more than doubled their business in the previous five years.

Strong new growth will bring some changes. First, it will not be uniform and will cause some lineup changes among major materials, with some growing considerably faster than others. Second, it will not be a waltz for all aspiring companies wanting to join in.

Among materials, polycarbonate finally will become the leader after 8.5% compound annual growth carrying it past 300 million lb per year, the report predicts. Falling to second slot will be nylon, whose 5.4% clip still will take it past 300 million lb. Unchanged in third place will be polyphenylene oxide-based resins, although this group will have the highest percentage growth at 9.6% per year. Polyacetal will have a more stately pace at 5.5% per year, and disappointing thermoplastic polyester a 7.7% pace to less than 100 million lb unless major new applications come through.

Engineering thermoplastics use will rise 8% per year in mid-80s

Millions of lb	1982	1987	Annual change, %
Nylon	243	315	5.4%
Polycarbonate	211	318	8.5
Polyphenylene oxide-based resin	112	177	9.6
Polyacetal	83	108	5.5
Thermoplastic polyester	53	77	7.7
High-heat resins	20	61	25.5
TOTAL	722	1056	7.9%

Source: Business Communications Co.

Outside these standard resins, another group of high-heat resins will be growing much faster—25.5% per year compounded—but from a very small base, BCC estimates. Rising to 61 million lb per year in 1987, this group includes polysulfone growing at 10.8% per year, polyphenylene sulfide at 10.2%, and polyarylates at 22%. One other material, polyphenylene ether, will climb from next to nothing to 20 million lb in 1987.

Although resin growth will be across the board, managing it will not necessarily be easy, especially for newcomers in a proliferating product scene. The report forecasts that technical and market competition will become very keen, although the basic industry structure will not change very much. One reason is that industry leadership might just get stronger in this concentrated business. According to the report, "There is an ever-widening gap in total pounds of engineering resins sold by the number one supplier. Number two supplier sells less than half of what number one sells, and number three sells about 70% of what number two sells. And company sales rapidly diminish after that. We do not see this situation changing to any great degree." □

Electronics, Carbon Fiber Markets Lure Specialty Chemical Makers

Competition in both these fast-growing areas, however, is intense, plus development costs can be high and prices of many items are declining

Specialties have become the catchword of the chemical industry. As commodity producers continue to experience narrow profit margins, there is a growing tendency for them to switch their efforts to development of specialty chemicals lured by the prospect of heftier profits.

Two areas that have attracted increasing interests are the chemicals needed for the fast-expanding electronics industry, and carbon fibers. But a note of caution was sounded at the joint meeting of the European Chemical Market Research Association and the U.S. Chemical Market Research Association in Venice, Italy. Competition in both areas is intense, development costs can be very high, and prices of many items are coming down.

In the field of electronics chemicals, "continuing competitive pressures dictate that management must be willing to constantly change and improve manufacturing technology," observes David S. Cox, director of the specialty chemicals department within SRI International's chemical industries division in Menlo Park, Calif. "The successful specialty chemicals supplier must work with its customers to coordinate its product development with manufacturing changes." Nevertheless, he adds, "the longer-range forecasts are still excellent, despite the current recession."

Cox: forecasts are still excellent

C&EN staff photo

As for carbon fibers, Richard M. Kossoff, head of the New York City-based company that bears his name, makes a point that "many firms have made substantial investments in high-technology markets on the assumption that they ultimately would generate significant return on investment. Some are beginning to realize, however, that the label 'high tech' does not automatically mean high profit, especially where accessibility of technology has led to excess penetration [of the marketplace]. The result is overcapacity, price discounting, poor returns, and management disallusionment.

"The lesson to be learned," he says, "is that before entering they must carefully pinpoint which segments are truly high tech and high profit. The carbon fiber composites industry probably will undergo a shakeout in the near future as some managements in the lower technology end lose patience with poor returns. Long range, companies with patient money, dedicated to developing the most advanced technology, from precursor to final product, will exhibit outstanding profit."

The electronics chemicals market has become one of the most popular areas for business diversification in the chemical industry, Cox notes. "High prices, the profit margins they often represent, and market growth rates that are well above the average for the chemical industry, have attracted numerous companies to the field."

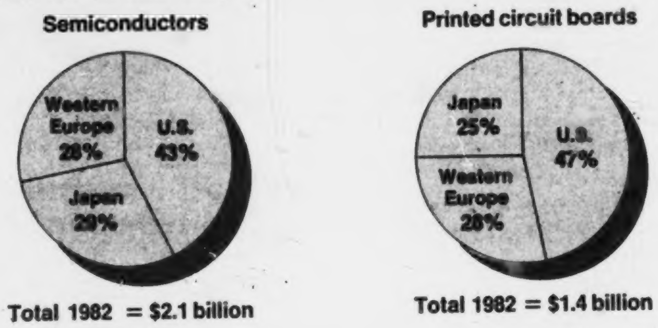
High prices also allow development work to be performed rapidly during the early stages of product use. Some developmental electron beam photoresists, for example, have sold for as much as $800 a liter. But because quantities of most specialty chemicals used in an electronic device are minuscule, their cost represents only a small fraction of the final cost of the product.

Confining his remarks to chemicals used in semiconductors and printed circuit boards, Cox believes that global sales could move up from last year's $3.5 billion to $6.8 billion in 1987 (based on a constant 1983 dollar value). During this five-year period, the geographical demand pattern will shift somewhat, he and his associate Alan R. Mills maintain. By 1987, they see U.S. sales accounting for 40% ($2.72 billion) of the total, followed by Western Europe with 31% ($2.11 billion), and Japan with 29% ($1.97 billion).

In contrast, the U.S. represented 45% ($1.58 billion) of the 1983 total, with sales in Western Europe amounting to 28% ($980 million), and in Japan, 27% ($950 million). Put another way, the annual rate of demand growth in Western Europe between 1982 and 1987 is foreseen at almost 17%, and in Japan nearly 16%, whereas that for the U.S. is put at 11.5%.

In dollar terms, semiconductors

Specialty chemicals sales in electronics industry by region breaks down this way



Source: SRI International

provide the largest outlet for specialty chemicals. Of last year's $3.5 billion in sales, 60% went toward semiconductors, 40% to printed circuit boards. This lead likely will be maintained through 1987, when semiconductors likely will account for 62% of the $6.8 billion total.

A wide variety of chemicals goes into making semiconductors. Substrate materials make up the largest functional class, 44% ($924 million) of last year's $2.1 billion. Here, silicon plays the dominate role, although some germanium, and compound semiconductors like gallium arsenide and indium phosphide—preferred in solid-state lasers and light-emitting diodes—are used.

Running a close second at 41% ($561 million) of sales are packaging materials needed to protect semiconductor devices and to support input and output leads. Foremost among these are ceramics, accounting for 41% of packaging chemicals' dollar value last year, pastes (about 22%), and encapsulating resins (10%). Also included are the more specialized die-attach adhesives (10%) used to bond the integrated circuit chip to its support prior to encapsulation. Miscellaneous items make up the balance, the most significant being conductive and rare-earth compounds, and soft ferrites.

Rounding out the classes of chemicals used in semiconductor manufacture are process chemicals and etchants (9%) and photoresists (6%). Processing chemicals embrace an exceedingly complex variety of products, Cox notes. At least 65 specific organic chemicals and upward to 20 inorganic chemicals are on the market. Mixtures of organic and inorganic formulations run into the hundreds, many of them specified by the users. Specifications governing impurity levels and the like can run as high as 40 per chemical. As a result, manufacturing and quality control are costly.

Printed circuit boards perform the very important function of interconnecting the many input and output leads of the semiconductor and other components in an electronic product. The U.S. holds the largest market share of the chemicals used in making them because of the high-performance products needed in aerospace, computer, and military applications.

Of the $1.4 billion in global sales of chemicals that last year went into printed circuit boards, substrate materials accounted for 61%. The most widely used items are glass- and paper-reinforced epoxy resin composites. The higher market share for glass-reinforced boards in Europe and the U.S. reflects the larger amounts of nonconsumer electronic equipment made there. Other components of the market are photoresists and process chemicals (16%), and plating and etching chemicals (13%). Adhesion promoters, cleaners, degreasers, inks, and the like make up the 10% balance.

In the field of carbon fibers, growth and profit opportunities a decade or so ago seemed virtually unlimited as early success in sporting goods spread to higher performance markets such as the aircraft and aerospace industries, Kossoff recalls. Projected demand for weight reductions, with associated savings in energy, appeared to justify high prices.

Some firms were predicting that U.S. carbon fiber sales would reach 5 million lb or more by 1983. As a result, capacity surged, now exceeding demand. However, sales this year will fall short of 2 million lb. Prices meanwhile have drifted down to the $15 to $35 per-lb range.

"When the high estimates were made," Kossoff remarks, "forecasters could not foresee that the world recession would severely weaken the auto and aircraft industries. Car producers simply could not pay a premium for weight reduction, and fewer [airplanes] were being built."

The economics of the business for individual producers is made worse by the larger number of suppliers. Today, there are seven U.S. makers of carbon fibers compared to three in 1975. Worldwide, there are about 16 polyacrylonitrile-based carbon fiber companies, about four that make fibers from pitch.

One tack that managements are taking is to integrate forward into production of carbon fiber prepregs, mainly by acquiring existing companies, and a final composite structural part. Kossoff notes that although fiber sells at an average of $27 a lb, the average selling price of prepregs stands at $55 a lb, and that of structural composites is $175 a lb. He estimates that fibers themselves account for 20% of sales, prepregs 55%, and structural composites 25%.

Despite the problems that have been encountered, Kossoff is optimistic that growth of carbon fibers and composites made from them will be good. "U.S. carbon fiber sales could grow from about 1.7 million lb this year to between 3.6 million and 4 million lb by 1987, and between 5.5 million and 6.6 million lb by 1992.

"This growth will reflect penetration of new markets made possible by higher propertied fibers that will allow specification in primary aircraft structures, selected auto parts, and defense products," he reasons. "In addition, lower-propertied pitch- and polyacrylonitrile-derived carbon fibers are growing in new areas, including asbestos replacement, furnace insulation, and protective clothing." □

NIH funding is up all-around, DOE gains a little

Congress continues to slog through its task of setting the final fiscal 1984 funding levels for the federal research agencies, having just completed work on the Department of Energy and National Institutes of Health budgets. Still to go are the budgets for the departments of Agriculture, Commerce, and Defense. And it's getting a bit late—the new fiscal year began Oct. 1.

Following the usual pattern, Congress was much more generous than the Administration in funding NIH, handing it an almost 12% increase instead of the requested 1%. But Congress appears to be tiring of the annual game in which the Administration requests less than it wants for NIH, knowing that Congress will take up the slack.

What most raised the ire of both the House and the Senate this year was the Administration's decision in January to fund only 3676 new and competing grants rather than the normal 5000. In April the Administration came back with a new budget proposal for NIH that did include 5000 grants, but it didn't ask for any more money to finance the additional 1324 grants. Instead it decided not to provide full-cost new and continuation research project grants, but to trim those awards by about 11% and 6%, respec-

Congress sets nothing but increases for NIH . . . .

$ Millions	1984 Appropriation	1984 Request	1983	% change 1983–84
National Institutes	$3954.0	$3609.9	$3539.9	11.7%
Cancer	1053.4	963.9	962.6	9.4
Heart, Lung & Blood	674.7	509.2	595.7	13.3
Arthritis, Diabetes & Digestive & Kidney Diseases	442.5	406.5	393.4	12.5
General Medical Sciences	366.8	338.2	321.0	14.3
Neurological & Communications Disorders & Stroke	325.5	292.3	287.4	13.2
Allergy & Infectious Diseases	305.7	280.8	270.3	13.1
Child Health & Human Development	265.0	247.3	244.9	8.2
Environmental Health Sciences	173.0	160.6	158.1	9.4
Eye	150.8	138.7	138.0	9.3
Aging	112.3	97.2	91.6	22.6
Dental Research	84.3	75.2	76.9	9.6
Research resources	241.9	201.1	213.2	13.5
National Library of Medicine	42.1	42.0	44.8	0.2
Office of the Director	26.7	26.7	25.7	3.9
Research facilities	25.0	19.9	17.5	42.8
John E. Fogarty Center	11.3	9.2	10.1	11.9
TOTAL	**$4301.0**	**$3908.8**	**$3851.2**	**11.7%**

. . . . but cuts some DOE energy research programs

$ Millions	1984 Appropriation	1984 Request	1983	% change 1983–84
Energy supply R&D	$1933.8	$2066.4	$2136.5	−9.5%
Nuclear	636.6	853.2	815.4	−22.0
Magnetic fusion	470.8	467.0	466.1	1.0
Supporting research and technical analysis	395.1	408.5	328.3	20.3
Environmental research	222.6	210.6	224.3	−0.7
All other	208.7	127.1	302.4	−31.0
Weapons R&D	829.6	819.0	742.2	11.8
General science and research	638.2	645.2	546.7	16.7
Fossil R&D	259.2	94.0	197.4	31.3
Conservation	150.9	71.1	133.6	12.9
TOTAL	**$3811.7**	**$3895.7**	**$3756.4**	**1.5%**

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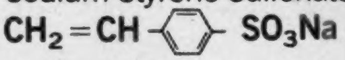

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tively. Reimbursements for indirect research costs also would have been cut, by about 10%.

Congress would have none of it. It restored all of the money that would have been cut from other programs to support the grants, including $53 million for the support of research centers, $25 million for biomedical research supporting grants to educational institutions, and $17 million for noncompeting research projects. And it added enough money to support the expanded grants program. Congress also rejected any arbitrary, across-the-board cuts in indirect cost reimbursements. Rather, the Senate Appropriations Committee suggested that as a way of checking indirect costs, those associated with each grant be shown on each individual award. The committee directed NIH to do so by July 1, 1984.

The Department of Energy's research programs did not fare quite so well. Funding for some programs is set well below fiscal 1983 levels, whereas others get major increases. Still, with three exceptions, Congress provided more money than had been requested by the Administration for the various energy research programs.

One of the exceptions is nuclear fission R&D, the budget request for which was cut 25% to about $637 million. Congress cut all of the $270 million requested for the Clinch River breeder reactor demonstration project. But then it turned around and added $53.4 million to the budget request for DOE's other nuclear programs. The second exception is found in the supporting research and technical analysis program, specifically in basic energy sciences. Congress cut the $25.9 million requested for a new National Center for Advanced Materials at Lawrence Berkeley Laboratory down to $3 million. Discounting that, funding for materials science is up 20% to $144 million, and funding for chemical sciences is up 9% to $82.5 million.

The third exception is general science and research where Congress cut $10 million from the budget request for high-energy physics—primarily from the construction budget—and added $3 million to the request for nuclear physics. ◻

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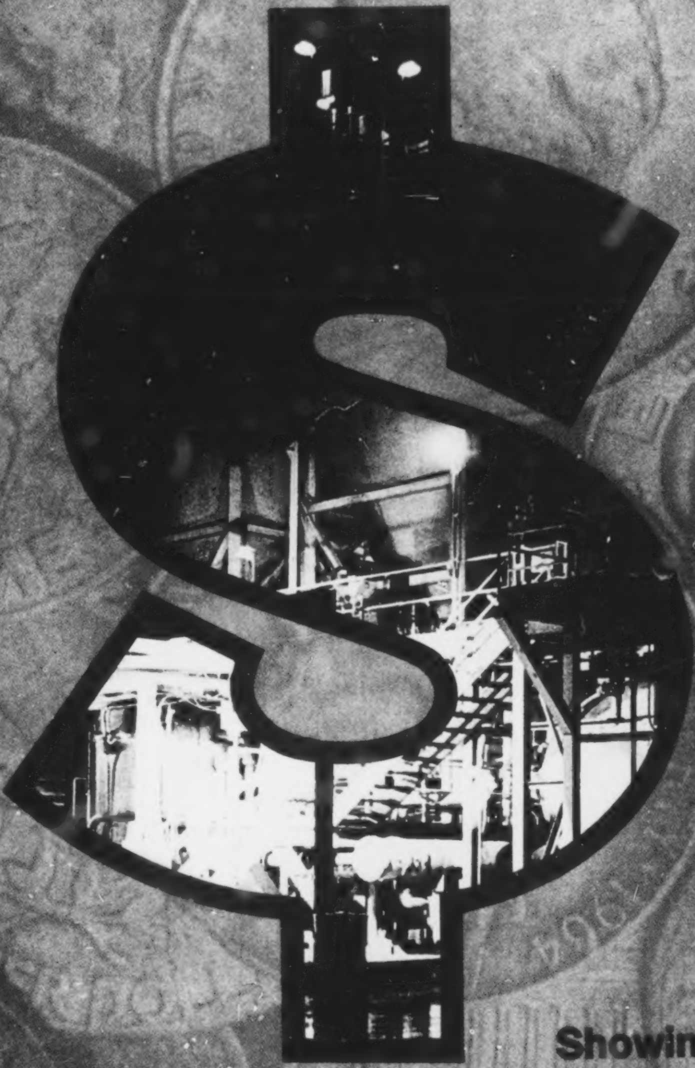

Chemical Earnings

Showing their new power Page 10

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NEWS

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POLYPROPYLENE: New process is simpler, cheaper

Union Carbide and Shell Chemical last week introduced a long-awaited process for manufacturing polypropylene. Called Unipol PP, the process, the two companies say, is much simpler, less expensive to install, and much more energy-efficient than conventional polypropylene processes.

In so doing, the partners have extended the revolution in thermoplastics technology since the mid-1970s. It began with independent new processes from Carbide and Dow Chemical for low-density polyethylene. Producing a new "linear" type of resin, these processes so transformed production economics that nearly all new LDPE plants in the world are expected to use them.

Since the first new processes, it has been only a question of time until analogous technology reached other polymers. R&D in this area has been top priority. Over the past year, rumors became rife that polypropylene would be the next breakthrough, and now the news is out.

Carbide has successfully demonstrated process at Seadrift plant

The new polypropylene technology—a gas-phase, fluidized-bed process—is targeted for existing polypropylene plants as well as new plants. It makes a full range of polypropylene grades.

Shell, the second largest U.S. polypropylene producer (after Hercules) with about 12% of capacity, and Carbide (not a current producer) also disclosed that they would build a 200 million lb-per-year polypropylene plant at Seadrift, Tex., converting a shut-down Carbide high-pressure low-density polyethylene plant. The two companies will share an interest in the plant, but declined to say what the percentage ownership for each would be. Output from the plant will be marketed by Shell. Completion is scheduled for 1985.

The new process will be offered for licensing worldwide by Carbide through its Unipol Systems department.

If the new process does what the two companies claim, it is indeed a wonder. Union Carbide executive vice president H. F. Tomfohrde says, "Our new Unipol PP process will turn back the hands of inflation on polypropylene technology. It will cost about one third less to build a new Unipol PP plant today than it cost to build a state-of-the-art polypropylene plant 10 years ago." During that time, according to Tomfohrde, construction costs have increased 130%. "Furthermore," he says, "investment costs for Unipol PP will be a minimum of 20% lower than those for any other 'new generation' gas- or liquid-phase polypropylene process."

Polypropylene at a glance

U.S. capacity: 5.1 billion lb

1982 production: 3.5 billion lb

1983 production (estimated): 4.4 billion lb

1983 value of production (estimated): $1.7 billion

Capacity utilization: 86%, third-quarter 1983

List price: 40 to 45 cents per lb

Major uses: Injection molding 40%, fibers 30%, film 10%

Producers: Arco Chemical, Eastman Kodak, El Paso, Exxon, Gulf Oil, Hercules, Internorth, Phillips Petroleum, Shell Chemical, Soltex Polymer, Standard Oil (Ind.), U.S. Steel

Roger B. Staub, vice president and general manager of the Unipol Systems department, estimates that it would cost 12 to 14 cents per annual pound to build a polypropylene plant using the new technology. A 300 million lb plant thus would cost $40 million to $45 million, he says.

Carbide says that converting an existing plant will cost about 40% less than building a plant with exactly the same capabilities.

The two companies say that operating costs with the new system will be much lower. According to the firms, the plant uses 75% less energy than a conventional liquid-phase polypropylene process.

James R. Street, president of Shell Chemical, says that the process requires no spent catalyst separation. And the production of by-product atactic polymer is so slight that it does not have to be removed. Unipol PP uses a Shell super-high-activity catalyst that has been optimized for the process, according to Street. The proprietary catalyst seems not to have been designed especially for this process, however. Street says the company has been making the catalyst for two years.

Unlike Unipol linear low-density polyethylene, the partners say, the new process gives a product with substantially the same processibility specifications as those for polypropylene made in conventional plants.

According to Carbide, not only can existing polypropylene plants be converted to the new process, but high- and low-density polyethylene facilities and even polystyrene plants can be converted. The conversion essentially would involve replacing the reactor and retaining most of the support equipment in the plant.

The reactor in the process is the same as the one used for the Unipol polyethylene processes. Thus, once the reactor is installed, the plant can be switched between different products. The change would take five or six days, Carbide says. However, consultants tell C&EN that the switch would be more complicated than that, because most polyethylene plants in the U.S. do not have a propylene feedstock mechanism.

It had been speculated that Hercules, the largest U.S. polypropylene producer, might be hurt by this new process, but since that company went into a joint venture with Montedison to form Himont, the danger is not so great, according to industry sources.

One consultant says that there are probably comparable overall economics between the Montedison process used in the joint venture and the new Unipol PP process. Hercules has declined to comment on the new Union Carbide/Shell process.

However, Carbide and Shell are claiming a 75% energy savings, whereas Montedison claims a 30% savings in power consumption. The difference, according to Carbide, is that pushing the gas around is more efficient, and therefore cheaper, than pumping liquid as in the Montedison process.

Consultants feel that Carbide and Shell will have to prove their process in actual plant use before a strong licensing effort can start to pay off. "After all," one consultant says, "Montedison already has two plants operating in Italy using its process, so it is much easier to assess the product." □

House passes stringent hazardous wastes bill

It took four days of debate spread out over four months, but the House finally passed a package of stringent amendments to the Resource Conservation & Recovery Act (RCRA), which governs the disposal of hazardous wastes.

The chemical industry has termed the bill punitive, saying compliance with its provisions will cost the industry millions of dollars. Universities are concerned because, if the bill is enacted in its present form, it may well lead to an end of their ability to dispose of their wastes in specially designed lab packs.

The bill requires the Environmental Protection Agency within 18 months of passage to issue regulations governing the disposal of hazardous wastes by small-quantity generators—those producing between 100 and 1000 kg per month of hazardous wastes. If the agency fails to do so, these generators will be required to meet the same regulations now imposed on large-quantity generators within 30 months.

It also prohibits dumping in landfills of noncontainerized liquid hazardous wastes and of 12 specific waste streams, mostly those contaminated with heavy metals, polychlorinated biphenyls, and halogenated organic compounds in total concentration greater than or equal to 1 g per kg, unless EPA determines that land disposal is not a threat to health or the environment in a particular case. EPA also would have to develop a schedule for reviewing all other hazardous wastes, both liquid and solid, to determine whether a prohibition on their land disposal is warranted. If the agency fails to complete the review within four and a half years, all methods of land disposal would be prohibited.

Florio: plugs number of loopholes

The House amendments would phase out over six years disposal of toxic wastes in unlined pits, ponds, and lagoons; require double liners in many existing facilities; and prohibit the injection of hazardous wastes into or above underground sources of drinking water.

Rep. James J. Florio (D.-N.J.), the primary author of the bill, says it plugs a number of loopholes in the current law. He points out that recently "much attention has been focused on the Superfund law and the problems it was designed to solve, namely, what to do with abandoned hazardous waste facilities that threaten public health. Yet without improvements in current law (RCRA), we are creating tomorrow's Superfund sites today." And it's cheaper to prevent rather than clean up, he says. EPA estimates the current cost of disposing hazardous wastes in accordance with RCRA at $90 per ton. On the other hand, the cost of cleaning up improperly disposed of hazardous wastes is about $2000 per ton.

The chemical industry's last chance for changing the bill is on the Senate floor. The Senate Environment & Public Works Committee has reported out a bill that is very similar to the one passed by the House. Committee chairman Robert T. Stafford (R.-Vt.) hopes to get that bill to the Senate floor before Congress recesses late this month. □

Chemical Earnings Accelerate Their Rebound

William J. Storck and David Webber
C&EN New York

It looks as if all the work that U.S. chemical producers have done over the past couple of years to lower operating costs and improve plant efficiencies finally is paying off. The chemical earnings recovery is well under way, indeed is accelerating.

In this year's third quarter both sales and earnings for chemical producers as well as oil companies and diversified firms that produce chemicals showed healthy increases. The rise was especially strong for basic chemical companies, whose earnings increased more than four times as fast as revenues.

For the full year in 1983, it is still nip and tuck whether chemical companies can get earnings up from 1982. There is little doubt that sales will be up for the year, but it will take an extremely strong earnings increase in the fourth quarter to pull the full-year total even with last year, let alone allow an increase.

Fortunately, chemical earnings for the fourth quarter are going up against an abnormally weak fourth period of 1982. So chemical companies may just be able to pull off the required gain for a full-year increase, expecially if there is any upturn in chemical pricing.

C&EN, therefore, is predicting that for the full year, chemical company earnings likely will be about even with last year, while sales will be up about 3%. Unfortunately this is going to make profit margins on sales a bit lower than in 1982.

Although producers got little help from prices in the third quarter, which according to government figures were unchanged from last year's third quarter, demand for

Chemical industry leaders for third-quarter . . .

Sales			Earnings[a]			Profitability		
Rank	$ Millions	Rank 1982		$ Millions	Rank 1982		Earnings as % of sales	Rank 1982
1 Dow Chemical	$2762.0	1	Monsanto	$99.0	1	International Flavors	15.1%	1
2 Union Carbide	2274.0	2	Dow Chemical	86.0	5	Freeport-McMoRan	13.7	2
3 Monsanto	1553.0	3	Union Carbide	80.6	2	Loctite	10.5	8
4 W. R. Grace	1506.0	4	PPG Industries	69.6	4	Nalco Chemical	10.3	4
5 PPG Industries	930.0	6	Hercules	43.8	6	Lubrizol	7.5	11
6 American Cyanamid	889.5	5	American Cyanamid	41.1	7	Petrolite	7.5	5
7 Celanese	811.0	7	Celanese	33.0	30	PPG Industries	7.5	13
8 Hercules	670.0	8	Rohm & Haas	32.1	13	Air Products	7.1	9
9 National Distillers	632.1	9	Ethyl	30.0	11	Chemed	7.1	10
10 Olin	486.3	10	Morton-Thiokol	29.6	17	Rohm & Haas	7.0	17

. . . and for nine-months 1983

Sales			Earnings[a]			Profitability		
Rank	$ Millions	Rank 1982		$ Millions	Rank 1982		Earnings as % of sales	Rank 1982
1 Dow Chemical	$8028.0	1	Monsanto	$303.20	2	International Flavors	15.6%	1
2 Union Carbide	6645.7	2	Dow Chemical	233.0	1	Freeport-McMoRan	11.5	2
3 Monsanto	4648.0	3	Union Carbide	190.2	3	Nalco Chemical	10.1	3
4 W. R. Grace	4465.7	4	PPG Industries	164.6	6	Loctite	9.4	11
5 PPG Industries	2720.0	6	Hercules	124.0	5	Petrolite	8.0	3
6 American Cyanamid	2612.0	5	American Cyanamid	111.2	8	Rohm & Haas	7.6	16
7 Celanese	2411.0	7	Rohm & Haas	108.9	12	Lubrizol	7.4	9
8 Hercules	1985.0	8	W. R. Grace	101.7	4	Chemed	6.9	7
9 National Distillers	1882.4	11	Air Products	81.1	9	Air Products	6.5	8
10 Olin	1449.7	10	Ethyl	79.1	10	Monsanto	6.5	10

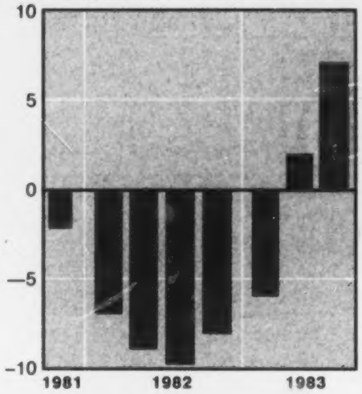
a After taxes. **Note:** For 30 companies listed on page 12.

Chemical industry third-quarter results

- Sales increased 7%
- Earnings climbed 34%
- Profitability rose to 4.3%
- Production jumped 12%
- Prices are almost flat

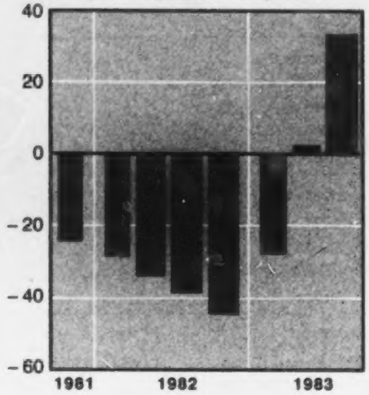
Sales

% change from year-earlier quarter



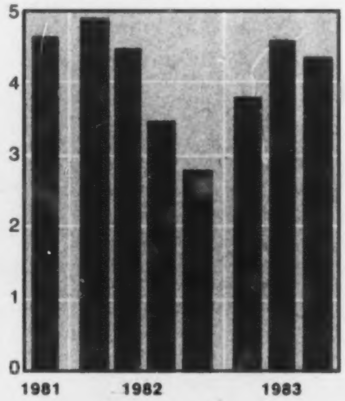
Earnings

% change from year-earlier quarter



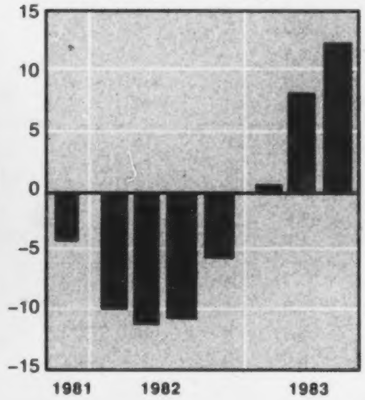
Profit margins

After-tax earnings as % of sales



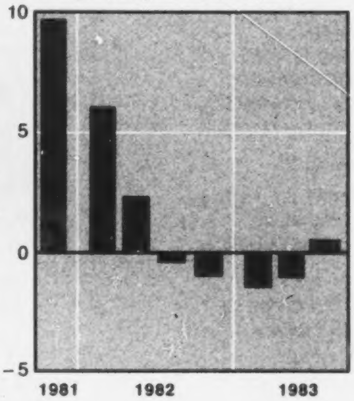
Production

% change from year-earlier quarter



Prices

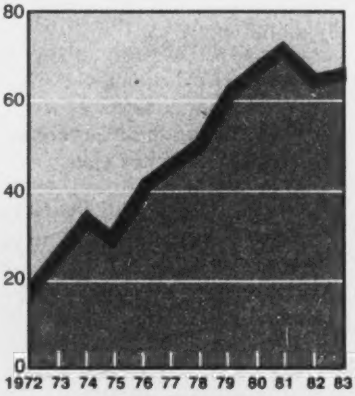
% change from year-earlier quarter



Sales for 1983 will be up about 2%, and earnings will struggle to stay even, dropping profitability slightly

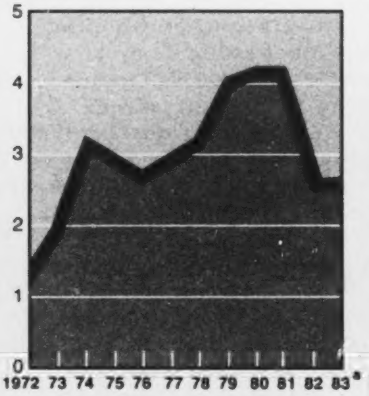
Annual sales

$ Billions



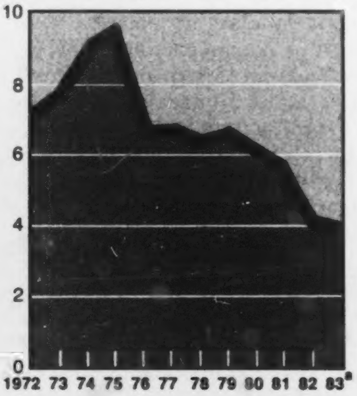
Annual earnings

$ Billions



Annual profit margins

After-tax earnings as % of sales



a C&EN estimates. **Note:** All sales, earnings, and profit-margin data are based on the combined performance of the 30 chemical companies listed on page 12.

Earnings gains far outstripped sales increases in third quarter

	THIRD-QUARTER 1983						NINE-MONTHS 1983			
	Sales	Earnings[a]	Change from 1982		Profit margin[b]		Sales	Earnings[a]	Change from 1982	
	($ millions)		Sales	Earnings	1983	1982	($ millions)		Sales	Earnings
Air Products	$ 416.2	$ 29.4	0%	9%	7.1%	6.5%	$ 1,246.1	$ 81.1	4%	1%
American Cyanamid	889.5	41.1	3	52	4.6	3.1	2,612.2	111.2	0	19
Celanese	811.0	33.0	14	def	4.1	def	2,411.0	60.0	3	200
Chemed	67.3	4.8	5	23	7.1	6.1	192.9	13.3	2	2
Crompton & Knowles	56.3	1.2	8	87	2.1	1.2	171.5	4.6	6	70
Dow Chemical	2,762.0	86.0	8	146	3.1	1.4	8,028.0	233.0	0	12
Ethyl	449.4	30.0	9	30	6.7	5.6	1,293.2	79.1	5	16
First Mississippi	57.8	0.7	17	−86	1.2	10.2	169.0	6.9	4	−49
Freeport-McMoRan	194.7	26.6	5	35	13.7	10.6	585.1	61.7	5	9
H. B. Fuller	109.2	4.3	37	72	3.9	3.1	315.5	9.7	34	47
W. R. Grace	1,506.0	28.1	4	−37	1.9	3.1	4,465.7	101.7	−2	−49
Hercules	670.0	43.8	5	58	6.5	4.4	1,985.0	124.0	−1	62
International Flavors	115.6	17.5	5	11	15.1	14.3	363.4	56.8	3	6
International Minerals	326.0	19.8	0	−19	6.1	7.5	1,136.0	54.2	−4	3
Loctite	59.0	6.2	11	72	10.5	6.8	171.6	16.2	6	60
Lubrizol	201.7	15.2	0	28	7.5	5.9	601.1	44.7	−4	9
Monsanto	1,553.0	99.0	3	39	6.4	4.7	4,648.0	303.0	−4	−1
Morton Thiokol[c]	479.3	29.6	—	—	6.2	7.5	1,370.7	72.7	—	—
Nalco Chemical	165.7	17.0	4	8	10.3	9.9	489.3	49.2	1	13
National Distillers	632.1	11.5	41	−26	1.8	3.5	1,882.4	36.9	37	−29
Olin	486.3	13.0	12	16	2.7	2.6	1,449.7	59.6	3	5
Pennwalt	247.3	13.8	6	89	5.5	3.1	731.7	26.9	0	10
Petrolite	72.2	5.4	−2	−21	7.5	9.2	216.4	17.2	−6	−24
PPG Industries	930.0	69.6	11	59	7.5	5.2	2,720.0	164.6	10	45
Reichhold Chemicals	194.7	5.5	2	400	2.8	0.6	568.0	16.3	−7	99
Rohm & Haas	458.7	32.1	4	87	7.0	3.9	1,442.1	108.9	0	75
Stauffer Chemical	285.8	−42.5	1	def	def	5.0	941.2	−22.5	−23	def
Union Carbide	2,274.1	80.6	5	14	3.5	3.3	6,645.7	190.2	−2	−32
Williams Cos.	381.6	8.0	0	def	2.1	def	1,143.7	19.1	−14	−24
Witco Chemical	358.0	13.9	8	83	3.9	2.3	1,024.4	37.0	2	67
Total 15 largest companies[d,e]	**$14,699.2**	**$634.8**	**7%**	**53%**	**4.3%**	**3.0%**	**$43,343.5**	**$1745.6**	**1%**	**−10%**
Second 15 companies[d]	**$ 2,511.3**	**$109.5**	**5%**	**−27%**	**4.4%**	**5.9%**	**$ 7,677.1**	**$ 392.2**	**−3%**	**−20%**
GRAND TOTAL[e]	**$17,210.5**	**$744.3**	**7%**	**34%**	**4.3%**	**3.4%**	**$51,020.6**	**$2137.8**	**0%**	**−12%**

a After-tax earnings from continuing operations, excluding extraordinary and nonrecurring items. b After-tax earnings as a percentage of sales. c Since merger of Morton and Thiokol, previous figures have not been restated, making comparison with prior data meaningless. d Division between large and smaller companies is about $375 million sales in third quarter. e Per cent change

chemicals picked up smartly. Production of chemicals and products was up about 12% over the previous year's third quarter. This pickup in production has raised plant use rates to the point where they can begin to take advantage of the efficiencies that have been instituted.

The exceptions to the good earnings performance were posted by companies that produce large quantities of agricultural chemicals. For most of these companies, the government's farm policies continued to clobber earnings as well as revenues in the third quarter.

However, overall it was a good quarter for chemical firms. Even the relatively unchanged prices, although causing complaints from producers, bode well for the future. With earnings increasing as they did in the third quarter, the lagging price picture continues to promise even greater earnings when prices do begin to turn around.

In one measure of the third quarter's performance, combined results for 30 leading chemical companies surveyed by C&EN increased substantially over last year's third quarter. For the 29 companies with comparable year-to-year results (Morton Thiokol is excluded, since after the merger of the two companies, earlier years' data were not restated) sales for the third quarter totaled $16.7 billion, an increase of 7% over third-quarter 1982. Earnings for these companies were nearly $715 million, a 34% increase over the same period last year.

As a result, profitability among the major chemical firms improved. The average profit margin on the cumulative sales of the 29 companies increased to 4.3% from 3.4% in 1982's third quarter.

However, for a change, the larger chemical companies by far outperformed the smaller ones. This seems partly because of the several agricultural chemical producers among the smaller firms.

NINE-MONTHS 1983		12-MONTH RUNNING DATA			
Profit margin^b		Change from 1982		Profit margin^b	
1983	1982	Sales	Earnings	1983	1982
6.5%	6.7%	4%	−5%	6.7%	7.3%
4.3	3.6	−2	0	4.2	4.1
2.5	0.9	−3	−18	1.4	1.7
6.9	6.9	0	−2	6.8	6.9
2.7	1.7	2	6	2.6	2.5
2.9	2.6	−4	−11	2.3	2.5
6.1	5.5	1	14	6.3	5.6
4.1	8.3	−18	−50	4.7	7.7
1.5	11.1	3	−3	11.6	12.2
3.1	2.8	30	21	2.9	3.1
2.3	4.4	−4	−45	2.6	4.5
6.2	3.8	−4	27	5.1	3.9
15.6	15.2	2	9	14.5	13.6
4.8	4.4	−4	−6	5.2	5.3
9.4	6.2	3	38	8.9	6.7
7.4	6.6	−5	−1	7.5	7.1
6.5	6.3	−5	0	5.8	5.6
5.3	5.4	—	—	—	—
10.1	9.0	−2	−5	10.1	10.4
2.1	4.0	23	−46	2.4	5.5
4.1	4.0	1	−7	3.5	3.8
3.7	3.3	−3	23	2.8	2.2
8.0	9.8	−7	−21	8.3	9.8
6.1	4.6	8	50	6.2	4.4
2.9	1.3	−10	75	2.3	1.2
7.6	4.2	−2	64	6.7	4.0
def	9.3	−16	def	def	8.7
2.9	4.1	−3	−49	2.4	4.6
1.7	1.9	−15	30	2.7	1.8
3.7	2.3	2	42	3.4	2.4
4.0%	**4.4%**	**−2%**	**−12%**	**3.6%**	**4.0%**
5.1%	**6.2%**	**−4%**	**−22%**	**5.1%**	**6.3%**
4.2%	**4.7%**	**−2%**	**−14%**	**3.9%**	**4.4%**

and profit margin averages exclude results of Morton Thiokol. def = deficit.

For the 14 larger companies with comparable year-to-year data (again minus Morton Thiokol), sales for the quarter increased 7% to $14.2 billion. Earnings jumped 53% to more than $605 million. As a result, profit margins rose to 4.3% from only 3.0% in the third quarter last year.

Smaller firms (sales below about $375 million) as a group did not perform as well. However, this group was weighted down by Stauffer Chemical, which had a $42.5 million loss in the quarter. Sales for the 15 smaller companies totaled $2.51 billion, a 5% increase from the third quarter last year. Earnings for the group amounted to almost $110 million, down 27% from third-quarter 1982. This gives an average profit margin of 4.4%, well off last year's 5.9%. If Stauffer is excluded from the group, earnings for the remaining 14 companies increased 21% over the year before, and profit margins rose to 6.8% from 6.0%.

The good results in the third quarter were not enough to produce a gain in earnings for the year thus far for the 29 chemical companies with comparable year-to-year data. For these firms sales were flat for the nine months at $49.6 billion. But earnings following two disastrous quarters were down 12% to $2.07 billion, producing a profit margin of 4.2% for the first nine months of 1983, compared with 4.7% for the same period last year.

For the larger companies, combined sales in the nine months inched up 1% to $42.0 billion. Earnings for this group, however, declined 10% to $1.67 billion, and the average profit margin slipped to 4.0% from 4.4%.

For the 15 smaller companies, nine-month sales dropped 3% from the comparable 1982 period to $7.68 billion, and earnings plunged 20% to about $392 million. Thus, average profit margin through the first nine months of 1983 was 5.1%, compared with 6.2%.

Chemical demand, of course, increased, but lower operating costs gave an extra boost to the earnings picture. Celanese chairman and chief executive officer John D. Macomber said, "I am particularly pleased by our improved profit margin. We have benefited from industrywide price increases and lower administrative and other operating costs." Celanese went from an $18 million loss in third-quarter 1982 to a profit of $33 million in the third quarter this year.

L. Stanton Williams, PPG chairman, said, "PPG's improved performance in the third quarter was based largely on the economic recovery and our own productivity gains and cost containment. We expect these factors to contribute to continued earnings strength for the balance of the year."

Productivity gains also helped oil and diversified firms in the third quarter. As in the second quarter, oil and gas companies and diversified companies with chemical operations reported increases in earnings far greater than those for sales revenues. Among the 19 largest oil and gas companies with chemical units, in fact, cost control measures, as well as some improvement in nonenergy segments, made possible an overall earnings increase of 7% despite an overall revenue decline of 5% (excluding all nonrecurring gains and charges). The disproportion between sales and earnings among the 25 largest diversified companies with chemical operations was even more marked: Operating revenues moved up a modest 5%, but earnings soared 32% overall.

Typical among oil and gas firms was Sun Co., which reported a 10% rise in earnings on a 5% decline in sales. "The continued improvement in our level of profit performance is largely the result of reductions in operating and administrative expenses," says Sun chief executive Theodore A. Burtis. Other companies say much the same.

They certainly could not credit oil and gas with the earnings rebound. As Shell Oil president John F. Bookout remarks in his company's earnings statement, lower crude oil prices and reduced demand for natural gas sent energy segment net income down. Positive factors, he adds, were increased crude oil production and higher gas prices. The pluses, however, evidently failed to outweigh the minuses in most cases.

As a result, although 13 of 16 energy companies reporting financial results registered a decline in revenues, 11 of them recorded increases in earnings. The most successful firm in the quarter was Occidental Petroleum, with a 405% jump in net income on 11% sales growth. Other healthy earnings gains were

Energy earnings rise despite sales drop, and diversified net income soars

	% chemical sales	THIRD-QUARTER 1983						NINE-MONTHS 1983					
		Sales	Earnings[a]	Change from 1982		Profit margin		Sales	Earnings[a]	Change from 1982		Profit margin	
		($ millions)		Sales	Earnings	1983	1982	($ millions)		Sales	Earnings	1983	1982
OIL AND GAS COMPANIES													
American Petrofina	11	$ 565.1	$ 23.0	5%	81%	4.1%	2.4%	$ 1,583.5	$ 31.9	−8%	−19%	2.0%	2.3%
Atlantic Richfield	8	6,378.4	405.1	−4	−1	6.4	6.1	19,220.8	1128.8	−3	−6	5.9	6.1
El Paso	15	1,100.0	25.0	4	−7	2.3	2.5	3,300.0	62.2	3	−6	1.9	2.1
Exxon	7	23,342.0	1225.0	−7	20	5.2	4.0	69,928.0	3360.0	−9	24	4.8	3.5
Getty Oil	2	2,900.0	184.0	−6	1	6.3	5.9	9,000.0	505.0	−4	−3	5.6	5.5
Gulf Oil	7	7,514.0	246.0	0	29	3.3	2.5	21,401.0	612.0	−5	5	2.9	2.6
Internorth	8	985.9	30.1	23	75	3.1	2.1	3,403.8	164.2	15	9	4.8	5.1
Kerr-McGee	13	898.3	39.7	−2	−30	4.4	6.2	2,584.4	101.3	−6	−34	3.9	5.5
Mobil	4	14,247.0	404.0	−7	42	2.8	1.8	42,937.0	1056.0	−10	30	2.5	1.7
Occidental Petroleum	na	4,908.0	126.7	11	405	2.6	0.6	14,413.8	163.1	12	6	1.1	1.2
Phillips Petroleum	15	3,890.0	176.0	−3	15	4.5	3.8	11,320.0	474.0	−4	−3	4.2	4.2
Shell Oil	15	5,122.0	449.0	1	2	8.8	8.7	14,638.0	1084.0	−3	−7	7.4	7.8
Standard Oil of California	3	7,654.0	509.0	−12	11	6.7	5.3	21,740.0	1187.0	−23	25	5.5	3.4
Standard Oil (Ind.)	9	7,200.0	629.0	−6	3	8.7	7.9	22,100.0	1454.0	−1	−0	6.6	6.5
Standard Oil (Ohio)	4	2,995.0	435.0	−10	−11	14.5	14.7	8,862.0	1113.0	−14	−21	12.6	13.7
Sun Co.	3	3,770.0	167.0	−5	10	4.4	3.8	11,290.0	392.0	−7	2	3.5	3.2
Tenneco	7	3,433.0	159.0	−5	−21	4.6	5.5	10,608.0	475.0	−4	−15	4.5	5.1
Texaco	3	10,600.0	331.0	−10	−19	3.1	3.5	30,600.0	977.0	−16	−10	3.2	3.0
Unocal (Union Oil)	11	2,731.6	180.2	−1	−15	6.6	7.7	8,012.6	447.9	−2	−23	5.6	7.1
DIVERSIFIED MANUFACTURERS													
Allied	25	2,610.0	98.3	6	61	3.8	2.5	7,999.0	322.3	0	28	4.1	3.2
Aluminum Co. of America	11	1,393.7	35.4	22	def	2.5	def	3,798.3	68.3	6	178	1.8	0.7
Beatrice Foods	5	2,372.7	87.1	2	3	3.7	3.6	6,965.9	242.1	2	5	3.5	3.4
Borden	30	1,074.5	39.6	2	−8	3.7	4.1	3,095.9	107.9	2	17	3.5	3.1
Borg-Warner	19	891.7	44.9	10	24	5.0	4.5	2,586.3	125.4	8	5	4.8	5.0
Diamond Shamrock	31	1,014.5	38.9	31	−8	3.8	5.5	2,848.3	69.8	18	−32	2.5	4.3
Du Pont	33	8,845.0	295.0	8	74	3.3	2.1	26,296.0	760.0	5	22	2.9	2.5
Eastman Kodak	20	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0	0	0.0	0.0
Engelhard	12	397.1	19.1	−26	12	4.8	3.2	1,625.5	53.2	15	12	3.3	3.4
FMC	38	841.6	45.6	−2	57	5.4	3.4	2,573.6	116.0	−1	9	4.5	4.1
General Electric	4	6,550.0	499.0	3	11	7.6	7.1	19,370.0	1445.0	2	12	7.5	6.8
Georgia-Pacific	12	1,709.0	3.0	20	def	0.2	def	4,827.0	89.0	20	−6	1.8	2.4
B. F. Goodrich	35	852.7	14.1	7	def	1.7	def	2,380.0	12.4	3	1278	0.5	0.0
Kaiser Aluminum	22	691.1	−36.8	−1	def	def	9.1	2,052.4	−116.9	−9	def	def	0.4
Koppers	34	450.8	20.1	−1	5	4.5	4.2	1,118.7	17.1	−7	7	1.5	1.3
Eli Lilly	27	708.1	103.9	6	24	14.7	12.4	2,280.6	342.0	2	10	15.0	13.9
3M	15	1,801.0	178.0	7	5	9.9	10.0	5,283.0	504.0	5	5	9.5	9.5
Merck	21	797.7	109.0	6	15	13.7	12.5	2,390.4	346.0	5	10	14.5	13.9
NL Industries	35	331.9	−0.1	−32	def	def	7.0	1,050.0	−47.1	−40	def	def	11.4
Northwest Industries	20	419.6	1.7	−7	−75	0.4	1.5	1,440.1	4.9	−25	−97	0.3	9.3
Pfizer	11	945.8	110.1	3	52	11.6	7.9	2,777.1	327.9	6	35	11.8	9.3
Tyler	35	247.3	6.7	10	56	2.7	1.9	689.3	13.6	5	77	2.0	1.2
Uniroyal	27	509.1	13.7	8	219	2.7	0.9	1,505.4	36.9	1	171	2.5	0.9
U.S. Steel	6	4,593.0	−41.0	2	def	def	def	12,816.0	−339.0	−12	def	def	def
Upjohn	17	477.5	37.0	11	84	7.7	4.7	1,480.8	126.5	8	25	8.5	7.4
Vulcan Materials	29	233.8	20.7	18	15	8.9	9.1	588.3	36.1	7	−22	6.1	8.4

a From continuing operations, excluding extraordinary and nonrecurring items. def = deficit. na = not available.

reported by American Petrofina, up 81%; Mobil, up 42%; Gulf Oil, up 29%; and Exxon, up 20%. The worst performers, all with declines in both sales and earnings, were Unocal (parent of Union Oil of California), down 15%; Texaco, down 19%; and Tenneco, down 21%.

For the fourth quarter, most oil and gas companies are taking a cautiously optimistic stance. Tenneco chief executive James L. Ketelsen, for instance, sees no sharp upturn, just "progressive improvements."

The economic recovery has had a far greater impact on the diversified companies with chemical operations. Although only 12 of the 25 largest firms managed to raise net income in the second quarter, 19 of them did so in the third. And not only have earnings generally improved from quarter to quarter this year, 17 of the companies reported earnings for the first nine months of 1983 higher than in the same period last year.

The standout among the diversifieds was Du Pont, which recorded an 8% increase in sales revenues and a 74% rise in earnings. "We are very pleased with the quarter's results," says chief executive Edward G. Jefferson. "This is the strongest quarterly performance we have had since the fourth quarter of 1981 as we continue to benefit from the economic recovery and ongoing cost-reduction programs."

Du Pont even managed to dodge the oil bullet; earnings from its energy segment actually rose slightly in the third quarter. The real boost, however, came from fibers, other polymers, and, to a far lesser extent, agricultural and industrial chemicals. After-tax operating income from the aggregate of chemical and related products grew 212%. Physical sales volume was up 11%, Du Pont says, and for the nine-month span, sales are running at 72% of capacity, compared to 67% for the same period in 1982.

There were many other examples of high earnings growth. Uniroyal continued its rocket ride with a 219% rise in net income, thanks mostly to strong performance by its chemical, rubber, and plastic materials segment. Company earnings, which shot up 142% in the second quarter, were up 171% in the nine-month period. Upjohn led the drug houses with 84% earnings growth. Big cost reductions were a significant factor in the gain, the company says. FMC, despite an overall sales decline, recorded a 57% earnings increase, mainly because of cost controls and higher revenues from industrial chemicals and defense equipment. Allied registered its first significant growth in earnings this year, a 61% jump stemming from good performance by its chemical, automotive, and aerospace segments.

There were losers as well, of course. Three companies posted deficits: Kaiser Aluminum & Chemical, with smaller, but still major, losses from aluminum and an increased loss from agricultural chemicals; NL Industries, hurt by continued weakness in the oil field chemical area; and U.S. Steel, with smaller, but massive losses from steel operations. □

Energy company petrochemical earnings surge

Energy companies produced a stunning overall turnaround in earnings from petrochemical operations during the third quarter. Eight oil and gas companies reporting after-tax net income from their chemical segments went from an aggregate deficit of $134 million in third-quarter 1982 to a combined gain of nearly $204 million in third-quarter 1983. The impact of the July-to-September surge shows in the nine-month data: Overall, the eight firms moved from a $7.9 million deficit to a $243 million net in a year-to-year comparison. At the end of the first six months of 1983, by contrast, energy company chemical earnings still were 25% below the first-half 1982 level.

The return of Gulf Oil's chemical segment to profitability was the most dramatic change. Even though as much as $28 million of the $63 million in reported earnings probably comes from the sale of property, the remaining income still marks the first nondeficit quarter for chemicals in a long time. Chief executive James E. Lee stresses higher product prices as the prime reason Gulf was able to make some money on chemicals again.

Higher chemical prices provided a bright spot for many of the energy companies, whose petroleum was still selling low in the third quarter. Internorth, for example, which recorded an impressive 30% jump in corporate earnings, gives most of the credit to its chemical segment, even though it accounts for only about 8% of the firm's overall sales. "The biggest factor contributing to the third-quarter improvement in primary earnings was higher prices for low-density polyethylene," says chief executive Sam B. Segnar.

Earnings statements from around the oil and gas industry comment in general on higher sales, improved margins, and increased capacity utilization for the chemical segments. Exxon, for instance, with chemical net up 111% during the first nine months, attributes its growth to a 6% rise in global chemical sales volume and continuing cost reductions. "Margins in the 1983 period have averaged below those of the prior year," notes chief executive Clifton C. Garvin Jr., "but improvement has occurred in the most recent quarter, particularly in the U.S."

AFTER-TAX EARNINGS ON CHEMICALS

	Third quarter			Nine months		
$ Millions	1983	1982	% change	1983	1982	% change
Exxon	$65.0	$ 16.0	306%	$150.0	$ 71.0	111%
Getty Oil	10.4	3.0	247	−19.7	22.0	def
Gulf Oil	63.0	−137.0	def	−2.0	−194.0	def
Internorth	5.5	−2.8	def	3.5	0.9	289
Mobil	7.0	7.0	0	0.0	33.0	−100
Occidental Petroleum	−3.3	−5.5	def	−3.5	−24.8	def
Shell Oil	14.0	−15.0	def	39.0	1.0	3800
Standard Oil (Ind.)	42.0	0.0	def	76.0	83.0	−8

def = deficit.

Canadian Chemical Sales, Profits Improve

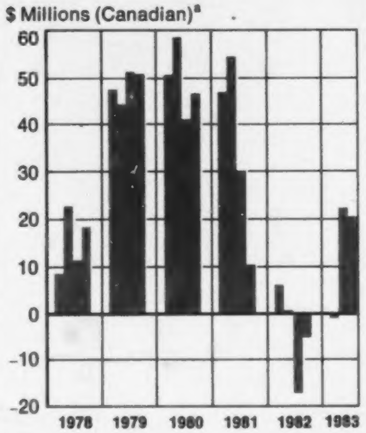
The third quarter was another strong one for Canadian chemical company profits. After five consecutive quarters during which profits were meager or nonexistent, the Canadian chemical industry has put together two profitable quarters back to back.

In the third quarter, for instance, C-I-L Inc. boosted its net income 800% over the third quarter of 1982, admittedly from an extremely small base. Du Pont Canada turned last year's $5 million (Canadian) loss into a $10 million profit. Celanese Canada and Union Carbide Canada also converted the red ink of last year's third quarter into black ink this year. For Carbide, it was the end of a five-quarter string of losses.

As a group, these four publicly reporting companies increased third-quarter sales 13.7% over those in the comparable 1982 period to almost $809 million. Their combined bottom line went from a $17 million loss last year to $20.5 million this year.

This is the stuff of which comebacks are made. It also is the stuff which stimulates dividends. Union Carbide Canada declared a dividend payable Dec. 1. It will be the first common share dividend paid by the company since June 1, 1982. And Du Pont Canada substantially increased its third-quarter dividend over those paid in the previous three quarters.

But, as gratifying as the third quarter was, all is not yet completely well with the Canadian chemical industry. Much of the earnings improvement reflects increased sales, rather than corresponding increases in prices. The all-important export market still is sluggish. And company earnings still have a long way to go to recapture those heady days before the recession.



Another profitable quarter recorded

a After-tax earnings of four largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont Canada, and Union Carbide Canada.

Du Pont Canada's experience typifies the disparity between domestic and export sales. Du Pont's sales in the third quarter were up 15% over last year to about $273 million. Sales in Canada were up 21%, but export sales were 8% lower. For Union Carbide Canada, the difference between Canadian and export sales performance is even more dramatic. Carbide's domestic sales increased 13% in the third quarter, but export shipments declined a hefty 47%.

Earnings up for three of four major Canadian chemical firms

	Nine-months 1983				Profit margin[b]	
$ Millions (Canadian)	Net sales	Change from 1982	Net income[a]	Change from 1982	1983	1982
C-I-L Inc.	$ 844.0	2.1%	$19.9	15.0%	2.4%	2.1%
Celanese Canada	284.5	23.3	5.3	c	1.9	d
Du Pont Canada	819.0	9.4	22.7	c	2.8	d
Union Carbide Canada	505.6	6.4	−5.5	c,d	d	d
TOTAL	$2453.1	5.2%	$42.4	c	1.7%	d

a Net income from continuous operations, excluding extraordinary gains or losses. b Net income as a percentage of sales. c Deficit in 1982. d Deficit in 1983.

The lingering effects of the recession and high up-front taxes on petrochemicals continue to plague Union Carbide. Sales of batteries, chemicals, food casings, film products, and home products all rose, but polyethylene and automotive products sales were lower. Sales of gases, metals, and carbon also were down from last year, primarily because of the low operating rates in the steel industry.

Still, Carbide has to be pleased with its third-quarter results. The company netted $3.4 million on sales of $179 million, which is a lot better than the $9 million loss it suffered in last year's third quarter. For the nine months, Carbide has reduced its loss from last year's $14.9 million to $5.5 million this year. These results, however, reflect a $7.5 million benefit that the company received as a result of government financial assistance given to Petromont, the Montreal petrochemical core company. Carbide has a one-third equity interest in Petromont.

For Celanese, the third quarter was particularly gratifying. It turned last year's $3.4 million loss into a $1.5 million profit, even though the third quarter traditionally is a weak one for the company. This is because the textile and garment industry, an important Celanese customer, usually shuts down for vacations in this period.

Ernest H. Drew, Celanese president and chief executive officer, expects sales and earnings to improve again in the fourth quarter. Other Canadian chemical executives tend to agree.

Earl Anderson, New York

Petrochemical surge from developing countries nears

It's no longer theory, a point in long-range planning. The new wave of basic petrochemical production from hydrocarbon-rich developing countries has reached the world's large chemical markets and will hit white-cap proportions barely more than a year from now. At that time, the core petrochemical units in Saudi Arabia will go through a rapid-fire series of startups.

For the many corporate eyes in developed countries watching this wave come closer, two experts speaking at the American Institute of Chemical Engineers diamond jubilee meeting in Washington, D.C., earlier this month had some polite but pointed advice: Accept the new output in the face of its overwhelmingly favorable economics, and, if you remain in petrochemicals, know precisely why. Trim operations that don't make sense, and plan expansions with the greatest of care.

Al-Mady: we intend to be competitive

From the heart of the new petrochemical development, Mohamed H. Al-Mady, senior vice president of Saudi Petrochemical Co., used conciliatory language but left no doubt of Saudi intentions: Saudi pricing will be geared "to make an orderly entrance into world markets. It is recognized that the economic health of Saudi Arabia is tied to that of other nations, particularly to the major trading partners in the West and in Asia. Because our future lies with our friends, SABIC (Saudi Basic Industries Corp., the principal state agency in industrial development) does not wish to disrupt the industry by undercutting competitors. But we do intend to market, be competitive, and to be profitable."

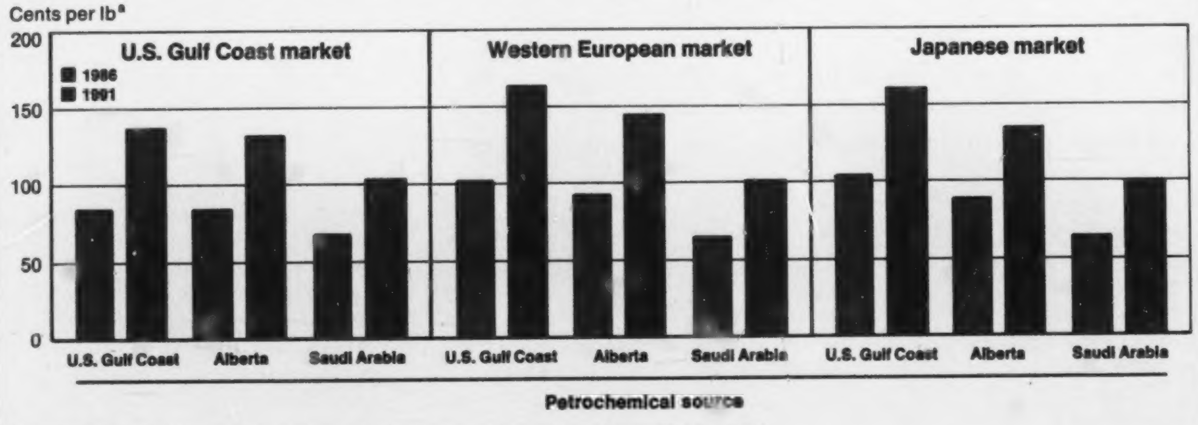
The Saudi production goal, Al-Mady continues, "once we have all of our plants on stream, is to produce 5% of the world's supply of bulk petrochemicals." With a large part earmarked for export, this will include more than a million metric tons per year of ethylene derivatives and another million metric tons of chemical-grade methanol.

How far will the new petrochemical wave go? Only up to a point, according to Al-Mady. "It is simply not possible for new producers to replace the traditional producers. In the near term, new producers do not have the capacity, and in the long term, it would make no sense."

Still, Al-Mady nudges developed-country petrochemical producers in new directions. "It makes far more sense, given the restructuring that is upon us, for the nations that traditionally have produced petrochemicals to shift more strongly toward the specialty products and processes that require the highly sophisticated specialists and technologies they already have."

For any doubters of Al-Mady's generalizing remarks, some eye-catching statistical backup was provided at the AIChE meeting by Andrew G. Kridl, vice president of the chemicals and resources division of SRI International. Kridl notes as a negative for traditional producers the new petrochemical supply from OPEC (Organization of Petroleum Exporting Countries). For example, to get a 25% annual return on polyethylene investment in the U.S. Gulf Coast market, Saudi producers will need to charge just 65 cents a lb in 1986 and $1.00 in 1991, compared to corresponding prices of $1.02 and

Saudis will be able to undersell U.S., Canada, in all major markets



a Prices to return 25% per year pretax on investment for linear low-density polyethylene. Source: SRI International

$1.62 by U.S. producers on the very spot. Notes Kridl, "In a business where a 1 cent-per-lb variation in manufacturing costs can spell the difference between profit and loss, the extent of the OPEC advantage cannot be underestimated."

Mainly for this reason, Kridl doesn't see many hopeful signs for traditional petrochemical producers in the 1980s. To be sure, declining feedstock costs likely will bring price stability and better earnings, and demand growth is more likely to go up. But the OPEC challenge will be a big one. "It's not surprising," Kridl concluded, "that there is a pronounced movement among the traditional chemical companies that have not integrated backward into crude oil to gradually abandon the pure petrochemical field."

For companies remaining in petrochemicals, Kridl offers a four-part survival prescription: Tighten up planning to avoid suicidal, industrywide expansion; concentrate on specialty instead of commodity grades; shut down excess capacity; and stiffen pricing policy.

"To sum up, petrochemical companies in the future must forgo the me-too approach and eschew bloody battles to maintain their market share. Unless a company has some sort of a competitive advantage, be it product cost, technology, or marketing, it should not contemplate becoming a new producer. The possession of capital funds alone is not a good enough reason for entering the petrochemical business. Also, companies already in the business that do not have [a] competitive advantage should dispassionately reexamine whether they can profitably stay in the game." ☐

Capacity increases have outstripped demand

Thousands of metric tons	Capacity			Demand,	Capacity use
	1980	1974	% change	% change	1981
U.S.					
Ethylene	17,946	10,522	71%	19%	72%
Low-density polyethylene	4,130	2,882	43	13	78
High-density polyethylene	2,757	1,478	87	61	73
Vinyl chloride	4,163	2,996	39	10	71
WESTERN EUROPE					
Ethylene	16,605	12,325	35	12	64
Low-density polyethylene	6,347	4,517	41	26	61
High-density polyethylene	2,477	1,566	58	37	64
Vinyl chloride	6,024	4,859	24	4	60

Source: SRI International

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Until November 30, 1983, the Board of Trustees, Group Insurance Plans for ACS Members is offering members who are under age 45 and not presently insured under the ACS plan the opportunity to apply for $15,000 of Term Life insurance and $15,000 of Accidental Death and Dismemberment insurance (AD&D coverage) by answering only an underlying single health question.

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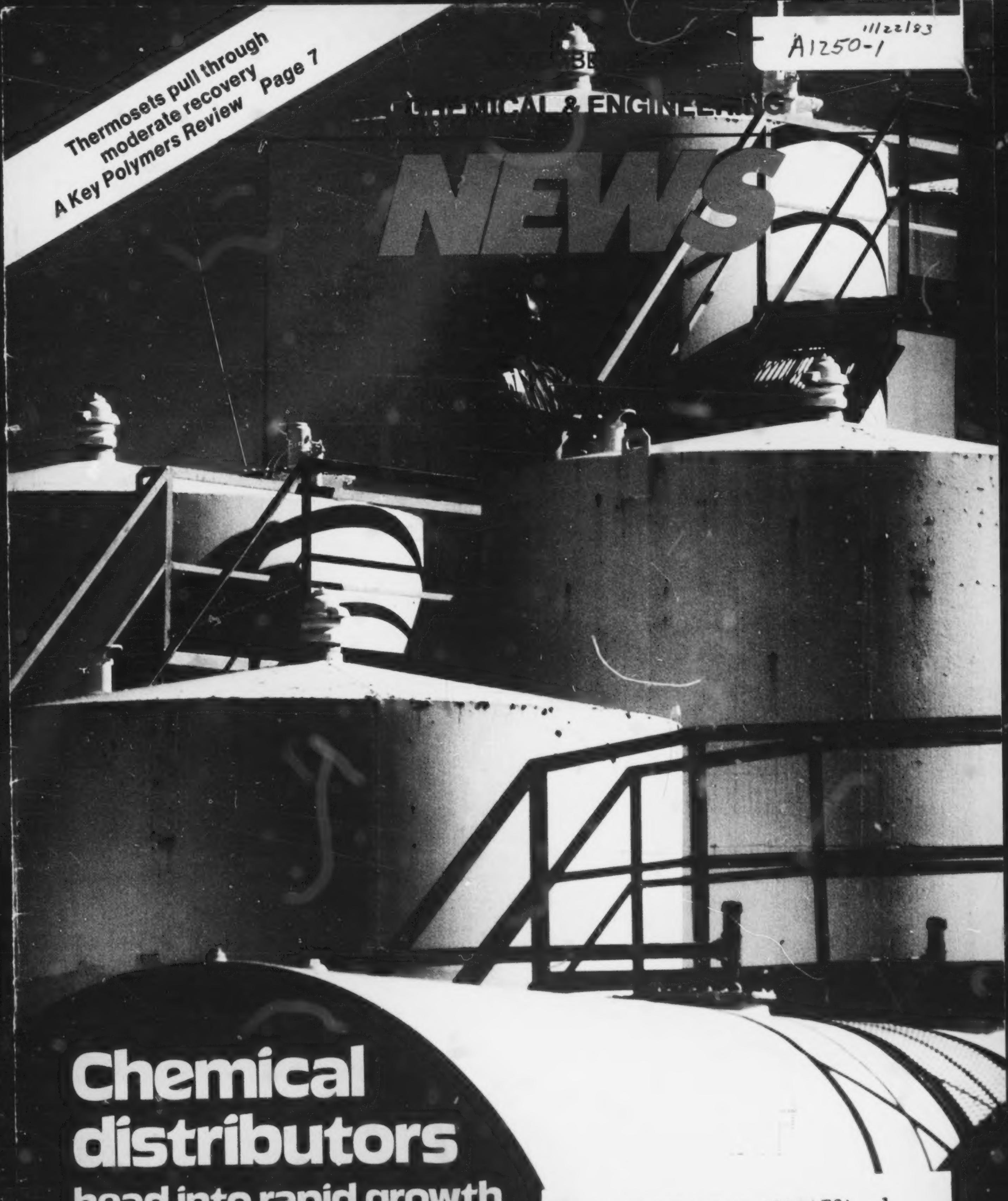

Thermosets pull through moderate recovery
A Key Polymers Review Page 7

Chemical distributors
head into rapid growth
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Cover: Bulk storage of liquid chemicals at Ashland Chemical's industrial chemicals and solvents division, Indianapolis

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NEWS

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NOVEMBER 21, 1983

News of the Week

- **Biotechnology stocks are still popular even though many have declined in value since their initial offering.** Page 4
- **Survey of hazardous waste sites requiring Superfund money finds 1000, but total costs cannot be pinpointed.** Page 5
- **The ecological changes that result from the destruction of rain forests may affect the atmosphere.** Page 5

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Business

Thermoset plastics sales have risen along with the housing and auto markets they supply, but capacity remains high. **Page 7**

The abrasives business is in for a strong growth period, mainly in the next five years, market researchers predict. **Page 11**

International Business

Mexican polyvinyl chloride makers seek export markets to take up slack of low domestic demand, excess capacity. **Page 12**

Government

The reorganized Agricultural Research Service stresses basic research, promotes grants to encourage new ideas. **Page 15**

Technology Policy

NAE president Robert White says the academy is uniquely qualified to deal with problems of technology and society. **Page 17**

Technology

Argonne chemists make artificial coal in attempts to determine coal's structure and how it was formed in nature. **Page 42**

New gas-treating agent developed by Exxon R&E removes hydrogen sulfide from gases, increases scrubbing capacity 40%. **Page 43**

ACS News

Congressional fellows Norine Noonan and Randall Wedin enjoyed their year working as aides on Capitol Hill. **Page 44**

Distribution Report

Chemical distributors gain acceptance by producers, now account for about 10% of chemical sales. Page 21

BIOTECHNOLOGY STOCKS: Still popular, but some are struggling

Three years after Genentech issued the first biotechnology stock to a tremendous welcome on Wall Street, biotechnology stocks are more popular than ever. Biotechnology companies, still mostly small firms, are issuing initial stock offerings with increasing frequency to a somewhat moderated, but still warm, response. This continues even though, for the most part, they are companies without either products or earnings. Most of the company stock involved still trades on little more than exotic promise and the number of Ph.D.s on the employee roster. After three years, the biotechnology sector is still being called an "investment fairyland."

Mixed results for biotechnology stocks so far in 1983

Company[a]	Price 11/11/83	Price 11/12/82[b]	% change[c]
AmGen	5⅞	18	−67%[d]
Biogen	12	23	−48[e]
Bio-Response	11⅝	6⅞	69
Biotech Research Labs	4¾	3½	36
Bio-Technology General	8¾	12½	−30[f]
Centocor	16¼	24⅛	−33
Cetus	12½	12¾	−2
Collaborative Research	9⅛	14½	−37
Damon	8¼	17	−51[d]
Enzo Biochem	22¾	19½	17
Genentech	30¾	40½	−24
Genetic Engineering	5⅛	3⅞	32
Genetic Systems	9¼	7⅞	17
Genex	14⅜	9¼	56
Hybritech	20¾	27¾	−25
Integrated Genetics	6	13	−54[g]
Interferon Sciences	4½	4⅝	−3
Life Sciences	15	3½	329
Molecular Genetics	13¾	15¼	−10
Monoclonal Antibodies	14	22½	−38
Novo Industri	64⅜	43	50
Over-the-Counter Composite index	277.3	232.61	19%

a All traded Over-the-Counter except Novo (New York Stock Exchange). b Or at initial offering if later. c Since 11/12/82 or initial offering if later. d First offering June 1983. e First offering March 1983. f First offering September 1983. g First offering July 1983.

The overall dip in the stock market in the past several months probably has affected biotechnology issues more severely than most, but performance is still good overall. Stock prices of 16 companies that went public more than a year ago rose an unweighted average of about 4% during the past 12 months. The Over-the-Counter composite index, by comparison, grew 19% during the same period. Almost all biotechnology shares are traded over the counter.

Of the 16 firms' stock prices, half went up in the past year and half went down. The big gainers were Life Sciences, up 329%; Bio-Response, up 69%; Genex, up 55%; Biotech Research, up 36%; and Genetic Systems, up 17%. The cost of the recent market downturn shows, however: Genex, at 14 3/8 now, was selling for 19 1/4 in early August; Biotech Research, now at 4 3/4, has plummeted from an August price of 15 1/2; and Genetic Systems, now at 9 1/4, sold for 14 in August.

Of the 16, the biggest losers were Monoclonal Antibodies, down 38%; Collaborative Research, down 37%; and Centocor, down 33%. As with the other companies, much of the decline has come in the past few months.

The least fortunate biotechnology stocks, however, have been the new issues. Five companies that have gone public this year—AmGen, Biogen, Bio-Technology General, Damon, and Integrated Genetics—have all seen the price of their stock decline sharply since the initial offering. AmGen, for example, went public at 18 in June. Since then, its stock has shrunk to 5 7/8, less than a third its original value. Biogen, now at 12, is 48% lower than its initial asking price in March of 23. Bio-Technology General opened at 12 1/2 in September. Now it sells for 8 3/4, 30% less. Damon, which went public in June at 17, now sells for 8 1/4, down 51%. And Integrated Genetics, which began at 13 in July, has declined 54% to 6 in mid-November.

The new companies on the block can take some comfort, perhaps, in that they probably are following a pattern. Most biotechnology stocks have had a history of losing value after an initial outburst of enthusiasm from Wall Street. With passing time and evidence that the companies are moving steadily toward development of some of their inventions, however, they have been rewarded by revitalization. Most of the older biotechnology stocks, in fact, now sell a good bit higher than their initial offering price.

Genentech stock, for instance, despite a 24% decline over the past 12 months, is still well above its October 1980 offering of 23 3/8. Monoclonal Antibodies stock, which has plummeted this year, remains well above its initial price in August 1981 of 10. And Hybritech stock is worth more than twice its initial offering price of 11 in October 1981. Perhaps the biggest success story in this regard is Enzo Biochem. The genetic engineering firm's stock went public at 1 in June 1980; recently it was selling for 22 3/4.

Some stocks continue to struggle to match their initial promise, on the other hand. Collaborative Research shares sold for 11 when the company went public in February 1982. Now they cost 9 1/8. Cetus stock, regarded by Wall Street before its initial offering with the same fervor accorded Genentech, now sells for 12 1/2, far below its March 1981 asking price at opening of 23. □

Thermoset Plastics Ride Durable Goods Recovery

Though not yet in sight of new production records or high capacity use, phenolics, polyesters, and epoxies manage moderate rebounds

Bruce F. Greek, C&EN Houston

As expected from the recovery this year in housing, automobiles, and other expensive consumer durables making up their dominant market, recovery also is well under way for major thermoset plastics. The top three covered in the following pages—phenolics, polyesters, and epoxies—are all taking part in the upswing.

But thermosets as usual don't have the go-power of thermoplastics (C&EN, April 18, page 11) even in this recovery year. Thermoset resin sales remain below previous highs of the late 1970s, and for some, volume may not reach new highs for a long time. As a result, some plant capacity has been closed permanently, and other capacity is shut down.

Even with a generous capacity deduction for shutdown plants, capacity is still high relative to expected sales for the next few years. The consequent low operating rates suggest strongly that downward pressure will weigh on prices, that profit margins won't match those of the past or what producers expect, and that returns on investment will be low. Hence, most industry analysts agree that new capital investment in these resins will be minimal.

Key Polymers

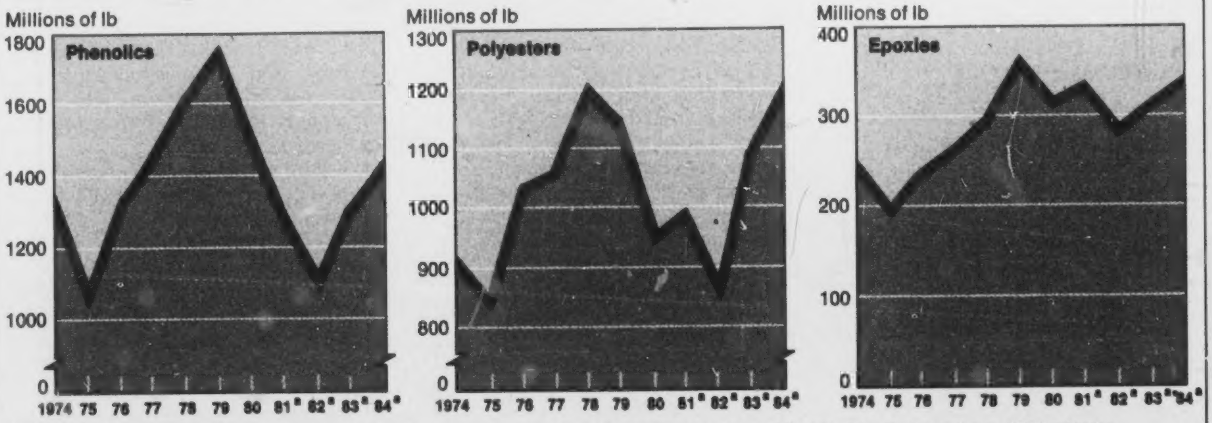
With the lone exception of unsaturated polyester, full recovery of these resins likely will take longer than 1984. That might be too long if another economic downturn takes hold in 1985 or 1986 as many economic forecasters are predicting.

The longer-term outlook then for these resins is not especially bright. They are considered moderately to almost completely mature products, so growth will be largely connected to constant-dollar gross national product, unless producers' new-use development begins to pay off.

Examples of such potential development are many. Transportation uses could boom anew under pressure of economic downturns and higher gasoline and structural materials costs. Such new growth in transportation has been expected for a long time although stymied time and again because of technical problems. One important block is that there seems to be no real solution to date on getting high production rates for many thermoset parts without capital investment much higher than for competing metal parts.

If these problems are ever solved, analysts are wide-eyed about the potential. Resulting inroads, they say, in transportation or housing could easily soak up all available thermoset capacity. But for now, such swift market capture doesn't seem to be in the cards.

Leading thermosets had no net growth in recent years



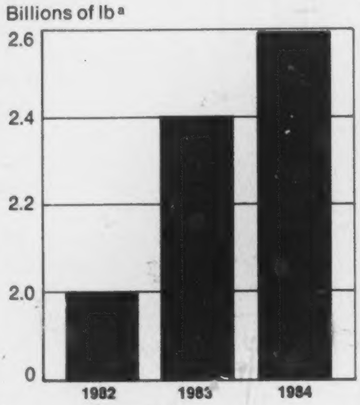
a Resin content only, to remain consistent with data for earlier years. **Sources:** Committee on resins statistics of Society of the Plastics Industry, C&EN estimates

Key Polymers

Phenolics

- ***Demand improving***
- ***Capacity shrinking***
- ***Prices up a bit***

PRODUCTION



a Gross weight, including solvents.

HOW MADE

Condensation of phenol and formaldehyde; subsequently cured by heat alone or with a crosslinking agent

MAJOR END USES

Plywood adhesives 50%, insulation adhesives 15%, molded items 10%, fiber and particle board adhesives 10%

FOREIGN TRADE

Exports—may reach 20 million lb in 1983, imports—negligible

PRICES

Bulk grades start about 20 cents per lb

COMMERCIAL VALUE

$600 million for production, 1983

Phenolics are tough, inexpensive resins well suited to mass use in construction, their dominant market. But heavy dependence on this gyrating outlet has put phenolics on a roller coaster in recent years. Right now, these thermosets are riding sharply up and have another year of strong growth in store in 1984. However, this recovery is put sadly in perspective by phenolics' dizzy 40% plunge in production from 1979 to the recessionary depths of 1982. It has been a wild several years.

In fact, recessions have been so severe on phenolics in the past decade that the materials have practically no net growth despite some strong gains in recovery periods like the present. Producers have tried to buffer themselves from the wrenching swings in conventional uses by developing new, higher-property grades but without much success. For example, General Electric tried this with its molding phenolics in the 1970s but left the business completely at the end of 1982, after producing these resins for more than 50 years.

For 1983 phenolics production is moving up about 20% from 1982, say analysts of this hard-to-measure product. Including various fillers, additives, and solvents in the compounded resins, production will reach about 2.4 billion lb. This level will top 1981 by about 2%. Another 8 to 10% production gain is possible in 1984 for a total of about 2.6 billion lb on the same gross weight basis.

Industry sources estimate resin weight alone at 1.32 billion lb in 1983 and 1.43 billion lb in 1984. In 1981, the committee on resin statistics of the Society of the Plastics Industry changed its reporting method to a gross weight basis from actual resin content. Hence, current data comparable to historical series must be unofficial estimates from industry analysts.

Figured either way, production of these resins still has a long way to go before regaining the old highs. Production back in 1979 exceeded 3.2 billion lb on a gross weight basis or 1.7 billion lb on a net resin basis. If after 1984 phenolics production falls into the typical growth pattern of 1 to 3% annually for mature products, a new production record will take a long time.

Adding to the problem are some constricting fundamental shifts in the phenolics business. One is a slow substitution among resins in various end uses, a trend generally hurting the more mature materials such as phenolics. Another, closely related, is a decline in recent years in phenolics producers and plant capacity. A third shift, also related, is declining consumer demand for some products using phenolics either for parts or processing.

Capacity for phenolics is and has been an elusive statistic. Among the many complicating factors is the multitude of producers, some of whom operate their equipment on irregular schedules or in tandem operations with other resins. Because the technology is relatively simple and capital investment low, small producers enter and leave the business frequently. Captive capacity and production also vary with economic ups and downs.

The driving force behind all this switching in producers, capacity, and production is the construction market, where at least 75% of phenolics wind up. By far the largest share goes into adhesives for plywood. Important secondary shares go into various kinds of fiber and particle board, insulation adhesives, and many smaller products used in homes and commercial buildings.

The vigorous recovery in home building in 1983 and anticipation of a continued brisk pace in 1984 account for much of the increased demand forecast for phenolic resins. One help has been added penetration of board wood in structural use as builders strive to reduce costs.

The many other uses of phenolics are small. Some, such as foundry core binders, also have recovered well, but they cannot affect the total demand significantly.

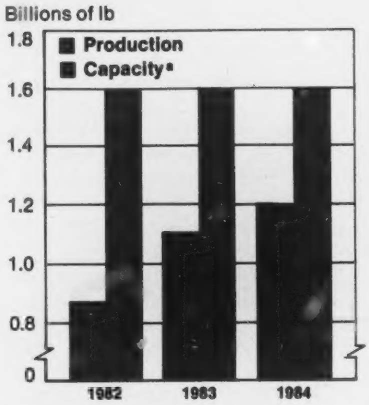
On balance, phenolics will swing along with construction as always. This means that another good recovery period in 1984 will depend crucially on the state of interest rates in construction financing. So far, so good, is the current outlook. But overdone credit demand could always change that in a year or so. Hence, forecasts for this resin show a caution light after 1984.

Key Polymers

Polyesters

- ***Demand well up***
- ***Capacity on hold***
- ***Prices steady***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Mainly polyesterification of maleic and phthalic anhydrides with propylene glycol

MAJOR END USES

Commercial, home, and industrial construction materials 30%, boats and marine products 20%, transportation equipment 10%, consumer products 10%

FOREIGN TRADE

Exports—may reach 10 million lb in 1983, imports—negligible

PRICES

List prices 50 to 60 cents per lb

COMMERCIAL VALUE

$600 million for production, 1983

A long-time center of growth efforts and new-use development in thermosets, unsaturated polyesters are rewarding their backers with the strongest recovery of the year among these resins. After stumbling 28% from the old production high point of 1.21 billion lb in 1978 to 865 million lb in 1982, polyesters are roaring back 27% in just one year to 1.10 billion lb in 1983. Next year another gain of 8 to 10% could bring production back to 1.2 billion lb.

Even if production soars to new records in 1984 and 1985, it won't strain capacity in the least. Although polyester capacity data have some of the same uncertainty as do phenolics statistics, analysts agree that capacity has been in large excess for several years and will stay that way. Capacity has been considered fairly flat, with estimates in recent years ranging up to 2.1 billion lb per year. That's too high, many analysts say. A more likely figure is 1.8 billion lb, and conservatives list 1.6 billion lb, taking out both reactor equipment that can be used for making other resins and plants that have been shut down for some time.

New capacity will not be added, analysts say, citing tough lessons for producers beginning in 1979, when important markets crumbled in boats and construction. Until consumers begin to feel freer with discretionary income, big-ticket luxury items such as boats will drag down polyester growth. Boats are especially important to polyester because of their relatively high resin content, on average 65% compared to 35% in some construction laminates.

Fortunately, polyesters have a wide array of alternate markets and are not lashed so tightly to construction as are phenolics. Between 75 and 80% of polyester resins go into fabricated products reinforced with glass fiber or, in a few instances, with other materials. Much of the nonreinforced polyester products go into the same end markets as do the reinforced products. For example, items cast from polyesters without reinforcement often go into decorative consumer products and so are included in that category along with the reinforced items.

Construction is the largest end use of polyesters with about one third of consumption. In this market, polyesters share with phenolics an uneasy dependence on business cycle ups and downs and, in turn, on interest rates. Although polyesters go more into interior uses such as bathroom fixtures and less into structural board, they received the same boost as did phenolics from the big decline in interest rates in the past year. For 1984, it's the divergence in interest rate forecasts that underlies the major differences in polyester forecasts in this market. Polyesters would be sensitive to any rate increases, which some forecasters hold as a possibility beginning in the second half of the year.

Boats and marine accessories rank next in use of unsaturated polyesters. The most recent peak for this application was in the late 1970s. The intervening recession years badly hurt this market and similar recreational products in transportation. Further recovery now appears modest, subject mainly to additional developmental work that could bring more market capture from metals and wood.

Most other uses of these resins are relatively small. Automotive uses are a big priority but even after more than 10 years of pushing polyesters as a major way to save weight and improve durability, producers admit that much potential has yet to be realized. Further developmental work improving consumers' and auto makers' acceptance of coatings on finished items may help demand, but most people in the industry doubt that this will happen in the next five years.

Such developmental work in polyesters is large relative to other thermoset plastics. It suggests potential for more capture of markets now held by other materials. Likely targets for future gains include tanks, wall systems, and corrosion-resistant products in which polyesters are already well established.

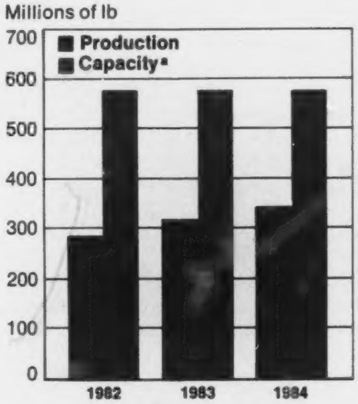
A major hindrance in this development work will be low profitability. Although growing nicely this year and next, polyester suffers low returns on investment, largely because of its excess capacity. Prices are no higher than a year ago, and polyester's value increase this year all will be due to higher volume.

Key Polymers

Epoxies

- ***Demand pushing up***
- ***Capacity to rise***
- ***Prices on hold***

PRODUCTION/CAPACITY



a First quarter, includes liquid and solid unmodified resin.

HOW MADE

Mainly reaction of bisphenol A with epichlorohydrin followed by subsequent crosslinking with hardeners

MAJOR END USES

Coatings 45%, laminates and composites 25%, castings and molded items 10%, flooring 5%, adhesives 5%

FOREIGN TRADE

Exports—declining to about 35 million lb in 1983, imports—negligible

PRICES

Most list prices $1.25 to $1.45 per lb

COMMERCIAL VALUE

$425 million for sales, 1983

On the premium-quality, high-priced end of the thermoset spectrum, epoxies have figured for a decade to benefit from quality-improvement campaigns in auto, electronics, and other durables markets. In practice, however, gains have been intermittent, yielding all too readily to recessions. From peak to trough in the rough business climate of the past four years, epoxy production dropped 21%. That was the lowest decline among major thermosets but was still a blow for a strongly development-oriented resin.

For 1983, analysts put epoxy output between 310 million and 320 million lb, up 8 to 12% from 1982 production of 286 million lb. A similar gain is expected in 1984, bringing the total to about 340 million lb. This still will be 6% below the record 361 million lb in 1979.

Plant capacity for unmodified epoxy resins, including liquid and solid types, has held steady since 1981 at about 580 million lb per year. But that is about to change. In mid-1984, Ciba-Geigy will complete a new plant at McIntosh, Ala., with a capacity of 100 million lb a year. Offsetting much of this addition, Ciba will then shut down capacity of 40 million to 60 million lb a year at Toms River, N.J., so the net gain will be relatively small, and additional production in 1984 will be quite small.

If 1984 production reaches 340 million lb, and available capacity totals 600 million lb, then the operating rate will not reach 60% of nameplate capacity. This level of operation doesn't suggest a highly profitable business, even though these resins command a high unit price and effective top capacity is considerably below nameplate because of complications in switching production of different grades. Capacity use looks especially bad in view of epoxies' slow expansion in their multitude of high-performance uses.

For example, coatings account for the largest share, about 45%, of epoxy resin demand. And a big use area of epoxy coatings is in automotive primers. Since auto production has swung up again, epoxy demand in this use also has begun to move up. Although recovery hasn't reached levels before the recession, autos are getting more and more epoxy coatings as demand for corrosion resistance increases. So epoxy has market penetration working in its favor.

The largest coatings use of epoxy resins is containers, particularly cans for beer, soft drinks, and some foods, all of which are considered mildly corrosive materials. Epoxy resins fit performance needs in these uses although at higher costs than for other resins, some of which apparently cause taste problems. Prospects for epoxies in container coatings are low inasmuch as most of the basic market penetration is over. Future gains will be just a small fraction above overall growth in can use. Long-range, a cloud on the container horizon is competition from plastic bottles, which could hurt this market later in the 1980s.

Other major coatings markets for epoxies are what might be expected of a high-performance material—marine, appliance, coil steel, pipe, and electrical products. Since epoxies already dominate some of these markets, growth there likely will be tied to the overall economy. Competition also exists in some areas, requiring developmental work by epoxy producers to keep ahead of other materials.

Reinforced epoxy resins used in a wide variety of laminates and composites account for the second largest epoxy use. Some of these applications are in aerospace, where performance is critical, resins very special, and prices lofty. No single use in this large group of end products now appears to be moving with enough steam to have much impact on total epoxy demand.

The many other uses of epoxy resins combine to account for about a third of the total. Some of these, such as electronic chips, also require extremely high performance. Their volume is tiny and selling prices very high, but they don't do anything for overall epoxy profitability.

Hence, epoxies face a strangely frustrating time of it financially despite their heavy participation in high-tech markets that promise, but so far have not provided, breakaway growth. Producers have capacity to spare for any such takeoff, but as of now, moderate growth is the outlook.

Chemical Distributors' Improving Status

Typically handled by distributors are bag-lots of chemicals such as this soda ash

David Webber, C&EN New York

If this were an ideal world, says one chemical distributor, chemical producers would see their distributors as so many natural and logical arms of their business. In reality, he concedes, many producers have long been more apt to see them as so many extra hands in the cookie jar. Too many manufacturers traditionally have resented distributors as low-investment, high-profit operators "not much different from used car dealers," he says. "We're fighting to change that image."

To a great extent, it is a battle that chemical distributors already have won. Chemical producers by and large now discuss their relationships with distributors in terms of "partnerships." They have created high-level executive posts dedicated to distributor sales. They have moved to formalize the producer-distributor relationship with policies that present a unified, corporate attitude. In some cases, producers are even referring customers whom they cannot or do not want to service to their distributor.

Distributors occupy a special place in the chemical industry. Unlike producers, which tend to be clustered in Texas, New Jersey, and a few other states, distributors are widely dispersed geographically. They are much closer in total to the downstream market, customers who use chemicals either in further manufacturing or as final products. Most producers admit that this proximity and concentration on limited areas—as well as their sheer numbers (more than 6000 of them)—make it possible for distributors to service customers who buy in less-than-truckload quantities much better than producers usually can. In return, however, distributors buy less-than-truckload shipments from producers at a discount and sometimes compete with producers in the same end-use market—two factors that can lead to friction.

Many chemical companies, of course, have had a carefully groomed relationship with distributors for a long time. But there has been a surge in both the quantity and quality of attention paid to distributor sales in recent years. Producers may not yet have learned to like their distributors for taking a cut of the sales dollar, but they have learned to respect them.

The reason is sales. The share of chemical shipments now accounted for by distributors is higher than it has ever been. Last year, according to Bureau of the Census data, distributor sales of chemicals and allied products totaled $17.4 billion, 10.3% of all sales in the sector. Impressive as that share seems, it understates the importance of distributor sales in the part of the chemicals and allied products spectrum in which distributors actually do business. Distributors carry only some of that sector's materials in their product lines; of total 1982 chemicals and allied products sales of about $169 billion, $82 billion worth, or 48.6%, was composed of products that distributors almost never handled. So in the $86.8 billion marketplace in which chemical distributors did do business last year, their presence was weightier, accounting for one out of every five dollars in sales.

In 1977, by comparison, distributor sales totaled $9.7 billion, or 8.1% of overall sales of chemicals and allied products, and in 1972, they amounted to $4.6 billion, or 8.6% of such sales, according to compilations of Census Bureau data performed by C. H. Kline & Co, a Fairfield, N.J., market research house.

A distribution dictionary

Chemical distributor. A firm whose primary function is the stocking and selling of chemicals produced either totally or mainly by others. (The definition excludes brokers and importers, who generally do not stock products.)

National distributor. Large, multilocation firm with 30 branches or more.

Independent distributor. Medium-sized and small firms. Such distributors may have several branches, but are limited to a regional or local area.

Distributor discount. Typically a 5 to 10% discount given distributors by producers to provide for both costs and profit margin on less-than-truckload business for which no value is added. Some distributors prefer to call the price break a functional allowance.

Freight allowance. For products sold on a delivered basis, the price reduction granted by producers to distributors who pick up product at the producer's plant or terminal.

As a result, distributors figure more prominently in the eyes of chemical management than ever before. At many companies that until recently left decisions on distributor use to the individual product or branch manager there is now an executive delegated exclusively to the task of bringing a single, corporate-level approach to distributor sales programs.

Celanese Chemical, for example, created the post of general sales manager-distributors in October 1982. The new position comes with broad authority. According to the company job description, it is meant to be the focal point for both the selection and termination of distributors and the planning of distributor marketing and sales programs as well as the primary link between chemical company management and the distributor market.

"You have to have this kind of position to be organized in your distributor relationships," points out Thomas L. Rogers, who holds the new post at Celanese. "It has to be a centrally controlled approach. The reason for a single authority on this for us is the development of policy that gives a clear understanding across all distributor lines of what is expected of the distributor and what the distributor should expect of the producer. We haven't had that in the past."

PPG Industries, about 20% of whose industrial chemical sales moves through distributors, also recently formed a corporate-level office to administer distributor business. "The creation of my new job is in recognition of the importance of distributors to PPG," remarks C. Michael Buerkle, who fills that new post. "Distributors are an important sector of our business, and we needed to give them as an individual category more specific attention."

Du Pont, on the other hand, maintains control of distributor programs at the department level. To build a corporate overview, however, the company has established a corporate distributor marketing committee. The committee functions more or less as a forum for the exchange of ideas between the various departments' distribution program managers. Du Pont does not have a corporate executive post dedicated to distributors.

Companies like Celanese and PPG are recent additions to a lineup of blue-chip chemical producers such as Union Carbide, Dow Chemical, Exxon, and Shell, which have well-planned distribution programs. "It's a coordination function," notes Robert Gunn, a principal at A. T. Kearney Inc., a New York City management consulting firm. "Somebody in the organization needs to keep track of what's happening, what the strategy is for each class of distributor, where they're going, and how the organization needs to position itself with distributors. Somebody needs to maintain the relationship with distributors."

It is the task of defining that relationship that historically has been a problem for producers. The widening of the distributor slice of the chemical market in the past 10 years not only has fostered new management positions, it has forced chemical producers to reassess their view of the distributor's role in the business of selling chemicals: Are distributors nothing more than companies that take care of a small customer, "afterthought" business, or are they now, by virtue of their extremely wide customer base, intrinsic to the marketing of chemicals?

"We look at the relationship with distributors as a partnership," says PPG's Buerkle. "We don't look at distributors as just being a method of moving excess volume when consumer markets are down."

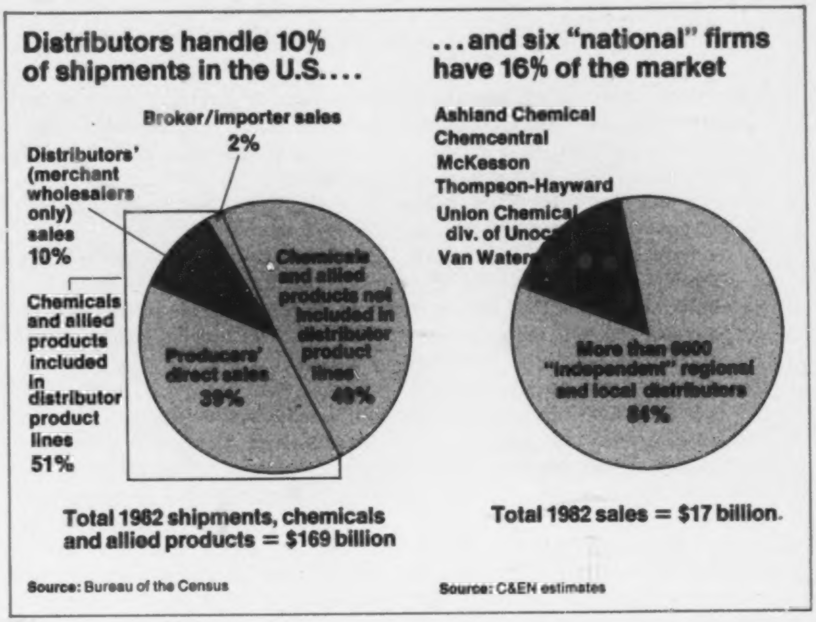
"Yes, it is a partnership," comments Gunn at A. T. Kearney, "but there are hawks and there are doves out there."

Producers consider three basic elements, he says, when they think of their relationship with distributors: Distributors are customers; they are an extension of the producer's marketing and sales force; and they often represent a business relationship that has been built up over time, amounting in many cases to a mutuality of interest.

"The doves recognize the value in each one of those elements, that you need to integrate them," he says. "The hawks say distributors are just customers. In fact, they say, 'We compete with them out there for some end-use business. We're going to take an aggressive posture with distributors. We don't trust them when they come back and ask for support because they're in a competitive situation.' I think there's substantial variation among producers."

Distributors tend to complain that producers overlook much of the benefit they derive from dealing with distributors. "They forget about the services a distributor can give: risk bearing, financing, basic technical service, handling more small customers than a manufacturer can," says James R. Kendell, executive vice president at Great Lakes Terminal & Transport Corp., a medium-sized chemical distribution firm based in Chicago.

The National Association of Chemical Distributors, a trade group with membership consisting of several hundred regional and local distributors—also referred to as "independents" to differentiate them from the large, multilocation "national" distribution companies—concurs. From its headquarters in Dayton, Ohio, the association issues a steady stream of newsletters and brochures touting the indispensability of distributors to the chemical industry.


Distributors handle 10% of shipments in the U.S....

...and six "national" firms have 16% of the market

Total 1982 shipments, chemicals and allied products = $169 billion

Total 1982 sales = $17 billion.

Source: Bureau of the Census

Source: C&EN estimates

A typical message shows a sprightly bird perched on the back of a dour-looking rhinoceros. In the natural world, the bird keeps insects off the rhino's back, something the lumbering beast, for all its size, can't do alone. With a deft bit of metaphor-stretching, the message compares the bird's activities to the services of the chemical distributor: It can take care of small accounts much better than the chemical producer, the rhinoceros, can itself. "The mutualistic symbiotic relationship," NACD somewhat redundantly labels the picture. "That's the way it should be in the chemical business," the message goes on.

NACD says there are several ways in which distributors enhance the marketing efforts of chemical producers. For example, distributors call on hundreds or thousands of customers each (an average 1600 for each NACD member), and they cultivate their customers closely. They also stock product close to demand, deliver quickly, and extend buying credit to their customers. In addition, NACD says, distributors provide technical know-how, bear the risks of inventory management, and provide extensive information about the marketplace.

"We have local stocks, quicker deliveries, and our salesmen call on accounts more often than the producer's salesmen do," says Robert V. Mann, vice president and general manager of the industrial chemical division of Thompson-Hayward Chemical Co. (a subsidiary of Harrisons & Crosfield Group). Thompson-Hayward, headquartered in Kansas City, Kan., is a multilocation, or national, chemical distributor and producer, with combined annual sales ranging between $200 million and $300 million. "There is less turnover in our sales force," he adds, "so we are able to develop a long-term relationship with our customers. We know the account backwards and forwards. And we can offer a package program: one-stop shopping and multiple products on one invoice."

But defining the new producer-distributor relationship entails more than listing what each can do for the other. Producers have reacted to the numbers—the growing share of distributor sales—by recognizing that they represent too big a portion of the marketplace to manage as a sideshow. What they would really like to know is to what extent the increased prominence of distributors is a long-term phenomenon and to what extent it is a recession-born ephemerality that will vanish with economic recovery.

Several developments during the

Producers are formalizing their relationships with distributors

Increasingly, chemical producers have been codifying the intentions and expectations they bring to a business relationship with distributors in the form of policy statements. Generally, a distributor policy statement lists the reasons a producer sells selected chemicals through distributors: typically, to penetrate markets the producer could not otherwise reach; to maximize less-than-truckload sales; and to provide dependable local sources of the producer's products. Most distributor policies also set out what the distributor can expect from the producer and what the producer expects from the distributor.

Following are excerpts from the distributor policies of two chemical producers—Celanese Chemical and PPG Industries—which have fairly recently centralized their management of distributor sales.

Celanese Chemical—To support its distributors, Celanese will:

- Formalize the Celanese/distributor relationship with a distributor agreement that defines policy provisions and Celanese's standard distributor terms and conditions of sale.
- Provide quality products on a consistent basis.
- Promote drum and small-volume bulk sales by referring such business to distributors.
- Provide technical and safety data support.
- Provide market information on a timely basis.
- Provide efficient, conveniently located terminals.
- Provide realistic pricing policies and responses that are consistent with market conditions.

PPG Industries—PPG's policy describes its commitment to distributors in similar terms, adding that it will:

- Provide marketing support through joint calls, sales and technical literature, advertising, and product and marketing training programs that help the distributor to be an effective representative of PPG products.
- Provide a commitment from marketing and regional sales management to assure that the relationship with the distributor will be a working one. PPG recommends periodic reviews of both parties' performance in the relationship.
- Provide frequent contact by PPG's sales representatives to share information on market conditions and trends, supply capabilities, new products and packages, and governmental regulations and legislation that affect PPG products.

PPG's distributor assumes these responsibilities:

- Provide customer service through a broad product line, short lead time delivery capabilities, and product quantities suited to the market.
- Share intelligence with PPG on markets, product uses, and competitive trends in the industries served.
- Maintain a responsible company image and sales position in the marketplace through a trained knowledgeable sales force, and use PPG product and national market knowledge to ensure a strong and informed sales force.
- Comply with product safety recommendations that are provided by PPG, and follow good in-plant practices.
- Maintain good, sound financial management to ensure his or her, and consequently PPG's, long-term growth position in the marketplace.
- Communicate future plans in business expansion or shift in business focus to ensure PPG adequate and continued product representation.
- Commit to the distributor-PPG partnership concept through the same open line of communication to which PPG is committed.

Celanese's requirements of its distributors are essentially similar.

recession had a major impact on the chemical distribution industry. Most significantly, high interest rates and cash flow squeeze forced most, if not all, chemical consumers to reconsider their inventory management policy. Leaner inventories at the end-use level put a lot of strain on producers. For distributors, the impact showed among the marginal consumers, the small- to medium-sized companies that traditionally had purchased their chemicals in bulk, but at widely spaced intervals. As recession forces squeezed them, the marginal consumers shifted in droves to more frequent purchases of smaller quantities. For most, this meant leaving the bulk marketplace, dominated by producers, and entering the less-than-truckload arena, dominated by distributors.

"When people saw the recession coming, they started going after their receivables and inventories," comments Great Lakes Terminal & Transport's Kendell. "People didn't want those five or six drums sitting around for months, so they started buying more frequently in smaller amounts. All this benefited us significantly."

At the same time, chemical producers were taking other steps to lower their sales costs. Sales forces were consolidated and, in many cases, trimmed. As a consequence, most producers and distributors say, the ability of producers' sales forces to call on, follow up calls, and otherwise develop small accounts fell victim to economics. But even if a producer no longer could handle a customer itself, it might not want to sacrifice the business entirely. So, like many consumers, producers turned to distributors. For the cost of the distributor discount—typically 5 to 10% of the product price—a producer could retain its presence in, and most of its revenues from, a portion of the market that was growing.

"What we've had in recent years is a reduction in producer sales forces," notes Thompson-Hayward's Mann. "Rather than covering three states, a producer's salesmen might be covering six or seven states now. They just cannot be in front of those customers often enough to keep the business from their competitors."

Although these factors undoubtedly contributed to the growth of the distributor share of chemicals and allied products shipments from 8.1% in 1977 to 10.3% in 1982, they cannot be seen as purely recession-related developments. To a great extent, changes in both inventory management strategies and in producer involvement in the less-than-truckload market are part of a long-term trend. Many participants—both producers and distributors—believe that what the recession did was to accelerate, rather than engender, these changes.

PPG, for instance, notes distributor sales manager Buerkle, has been out of small-quantity industrial chemical sales for years. "It's the cost of doing business," he explains. "We can't afford to be in the [less-than-truckload] business." He estimates that there are probably some 70,000 end-use customers for chlorinated solvents, an important product line at PPG. "There's no way in the world we can afford to go out and service all those accounts."

As a result, more than 85% of PPG's chlorinated solvent sales are handled by distributors.

Starting with such basic logistics, many say, the list of reasons for the general move away from small-quantity business on the part of producers grows. "Many producers have discovered on their own or through the actions of other suppliers that they can rely on resale people such as us to actually give them a greater net back than they themselves can achieve," says Richard T. Hough, chief executive officer of Chemcentral Inc., a $400 million per-year multilocation distributor based in Chicago. "We handle a lot more products than they do, can put together a bigger package than they can—a package more suitable to the customer—and also have a pretty expansive sales force. They employ us for that."

Besides pruning their sales forces, A. T. Kearney's Gunn points out, chemical producers also have rationalized their product lines. This means that producers are more often unable to deliver products to customers as effectively as distributors can, because they do not have as many complementary product lines, he says.

Another long-term trend that has turned business toward distributors, Gunn says, is computerization. With the widespread adoption of computers, the duties of purchasing managers have broadened. "It's not uncommon for them to be buying a thousand items," Gunn explains. "They're too busy to have a million sources for their product lines, so they end up going to a distributor who can serve them well across a broad product family for products they can't order in straight load quantities on a frequent basis. So the distributor is filling a real need that's marketplace-driven."

Rogers: centrally controlled approach

Buerkle: distributors are key sector

Gunn: a coordination function

Of prime interest to both producers and distributors, however, is the future of the current trend toward leaner inventories. In the short run, many agree, inventories will remain lower than is normal at this point in a recovery, a factor that will keep business that is entirely related to the recession in the hands of distributors.

"My feeling is that a lot of people have looked carefully at their inventory and cost control and are going to be much more active in managing that effectively, at least for the next year or so," remarks Great Lakes' Kendell.

So far, at least, surveys of inventory positions around U.S. industry support that assessment. "With the strong performance of the economy so far this year, it is surprising that inventories have not risen as broadly," comments Charles T. Haffey, vice president for the corporate purchasing division at Pfizer, in the National Association of Purchasing Management's report on the economy in October. "This may indicate a fundamental change in business strategy regarding inventory policy. Purchasing managers seem determined to operate with lower inventories, even in the face of continued demand for goods."

Consequently, fewer purchasing managers reported that their stocks had increased in October than did so in September or August, NAPM reports. And 21% of those surveyed replied that they actually had lowered their inventory levels in October.

Many believe that the new attitudes toward inventory management manifesting themselves now in reports like NAPM's will continue to form inventory management policy in the future. "The inventory trend will continue," says Celanese's Rogers. "The reason is a combination of the financial advantage and having companies now that, being computerized, can handle smaller inventories over the long run. I don't think we'll ever go back to the days of huge inventory stocks unless a shortage comes along. On a general day-to-day basis, I see inventory maintenance in the future at some percentage below what it's been in past good times."

PPG's Buerkle agrees. "I personally believe that we're going to see more inventory reductions, especially now," he says. "I never did understand why people bought something three or four times a year [in bulk] instead of using the services of a distributor and improving their cash flow."

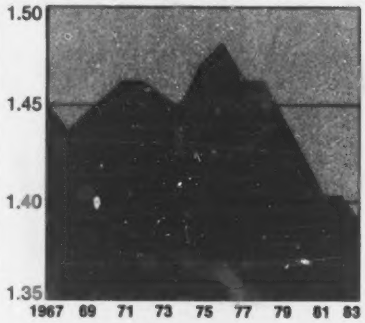
Not everyone is sure that the lean inventory trend will last, however. "It's a question yet to be answered," remarks Chemcentral's Hough.

To some, the answer is that the change in inventory policy is part fundamental, part cyclical. At Du Pont, for example, Maxwell L. Cluett, distributors manager in the chemicals and pigments department, points out that what some people might consider evidence of a long-term trend could be deceptive.

"It's true, some large and mid-size consumers during the recession shifted from buying truckload quantities from a producer and will on a short term purchase smaller quantities from a distributor," he says. "That has its ups and downs going through a recession, but it's a temporary thing. The [major change in inventory management that] people are talking about is something that exists now as we are just coming out of a couple of back-to-back recessions, so it may seem like it's a prolonged kind of happening. But if you go back historically, back to World War II, that has not been the trend through all that period."

Inventories trend downward since mid-1970s

Inventories-to-shipments ratio[a]



[a] 10-year running average for seasonally adjusted June data for chemical and allied product companies. **Source:** Commerce Department

At any rate, Cluett says, charting the future longevity of lean inventory management in the chemical consumer industries is nothing more than guesswork. "But that's not the important side of the growth of the chemical distribution industry anyway," he argues. "The inventory control aspect of the chemical industry is not the future of the chemical distribution industry."

Cluett's analysis homes in on the question of whether the chemical distributor slice of the pie will continue to grow and, if so, how much. When most analysts describe the distribution market, they talk in terms of a 20% share today, growing to 25%, or even 30% in the most optimistic forecasts, by 1990. Cluett stresses that the 20% share base analysts talk about refers to only that part of the chemicals and allied products market, the 51.4%, in which distributors currently do business.

"So if you say that chemical distributors are going from a 20% share to a 30% share, that says to me that you're just going to sell more of the same products that you're now handling for producers," he says.

This type of analysis ignores the enormous 48.6% of all chemical shipments in which distributors at present play no role, Cluett says. "I don't think that [increased sales of products currently in distributor product lines] is where the growth

Producer pricing for distributors: changes may be coming

There are two major elements in a producer's distributor pricing policy: the distributor discount and freight allowance. The distributor discount, which typically ranges from 5 to 10% depending on the product, is meant to cover a distributor's costs and provide a profit margin. Some distributors prefer the label functional allowance, which they argue clarifies the reason for the price break.

The freight allowance, which affects only products normally sold on a delivered basis, is meant to cover the transportation costs of a distributor who picks up product at the producer's plant or terminal.

Freight allowance was a relatively straightforward matter before deregulation of the trucking industry. Set rates meant a producer knew exactly how much it would cost to transport product from point A to point B. The competitive and soft pricing that succeeded deregulation has made it very difficult for producers to judge what a distributor is really paying for transportation now. For this reason, many producers worry that some distributors are reporting and receiving an allowance for the highest carriage rates on the market while actually paying less.

And, although most hesitate to discuss it, there is the problem of "phantom freight": distributors receiving freight allowance for the cost of transportation from point A to B, but actually delivering the shipment to a third point somewhere between—and pocketing the difference. There is much debate on the prevalence of "phantom freight," but little doubt that it occurs.

One solution, some producers say, would be to make all sales to distributors f.o.b plant. But most think that option too extreme. What is more likely, many say, is a trend toward more negotiation on the size of the freight allowance, and, in some cases, changing the freight terms from freight allowed to freight equalized.

If there are changes on freight allowances, they won't go down easily. "Distributor managers," says an executive at one distribution firm, "get vehement on this subject."

The distributor discount seems less vulnerable. "There are people who think that the distributor's discount is too much," says A. T. Kearney consultant Robert Gunn. "That's not really the case. Distributors operate on very thin margins."

of the chemical distribution industry is," he argues. "I think it will be the new products, those products not now being handled by distributors. If you calculate future growth on that basis, I'll agree to the share going from 10% to 15%."

As an example of products moving from the nondistributor into the distributor sector, he points out that titanium dioxide was not sold through distributors just three years ago. At that time, Du Pont decided it wanted to increase its TiO_2 sales effort directed at the less-than-truckload market. The company recently had consolidated the product lines of several departments and simultaneously reduced its sales force. This made it difficult for the company to service even those small accounts it already held, never mind add new ones. "The only practical, economical, and efficient way to do that was to work through distributors," Cluett explains. "That was the basic motive."

In the chemicals and allied products sector, there are lots of products not now sold through distributors, he says. "Tomorrow or next year, some of them may."

Undoubtedly, it will be a combination of factors—tighter inventory control, reduced producer sales forces, and the reformation of distributor product lines—that will lead to growth for chemical distributors in coming years. Whatever the primary reason may be, distributors do agree that they will do well. "We expect to see our market share grow faster than the chemical industry," remarks R. G. Parsons, vice president and general manager of the industrial chemicals and solvents division at Ashland Chemical Co., a multilocation chemical distributor that is also a producer. For the next five years, Parsons anticipates company sales growth to average 1% more than the rate of the gross national product. In Ashland's 1983 fiscal year (which ended Sept. 30), the chemical company had sales of $1.2 billion, roughly 50 to 60% of which belongs to the distribution segment, Parsons says.

Although there is plenty of agreement that chemical distributors are entering a period of prosperity, there is less on whether all members of the industry will benefit from it equally. The national chemical distributors are in general far larger than even the largest independent competitors, with much more extensive personnel and financial resources.

Mann: long-term relationship

Cluett: growth will be in new products

Parsons: increasing market share

The six biggest nationals are Ashland Chemical, Chemcentral, McKesson, Thompson-Hayward Chemical, Union Chemicals division of Unocal, and Van Waters & Rogers. These six companies' combined distributor sales last year were $2.8 billion, or 16.1% of the overall chemical distribution market. The remainder was shared among some 6000 independents. These smaller distributors realize that the nationals will be trying to parlay all the advantages of size into increased market share in coming years.

Calculating a national's clout in the marketplace, however, is not just a matter of comparing its total earnings or asset base to that of an independent competitor. Though a national operates anywhere from 30 to 70 branch terminals compared to a typical independent's one to five branches, the big companies generally run each branch as an individual profit center.

The need to limit the scope of an individual distribution facility's marketing area and number of customers is obvious when one considers the logistics involved. Perhaps the most important aspect of a distributor's customer service is its ability to deliver orders quickly. It does no good for a customer to shift to a leaner inventory if it cannot count on being able to restock rapidly. At Ashland, for instance, a spokesman explains, if a particular branch's customer base grows too large, the company probably will establish an additional branch.

"The distribution business is very much a local, hands-on, entrepreneurial type business," remarks Ashland's Parsons. "Since we are a big company, it's fundamentally important to us that we maintain that character. So the district manager is the key person. The rest of Ashland is structured to be a support organization."

It is in the support function that the nationals display the advantages of size. Parsons, for instance, notes that the big companies' financial strength makes it possible for them to maintain large technical service groups, analytical chemists, and material safety data sheet programs more easily and, in general, more extensively than the independents can. Also, Chemcentral's Hough points out, size is an advantage, because by representing a supplier in several cities, the supplier can deal with a single party.

Celanese's Rogers agrees. "The nationals have very sophisticated business staffs from the financial, legal, and safety points of view," he says. "They also have broader geographic coverage because some of their customers have multiplant locations that they serve. This doesn't mean independents aren't as careful and ethical."

Rogers also agrees that many producers find the idea of having a good chunk of their national distribution done by one company appealing. If a chemical company were distributing small shipments around the country, he says, it would be a lot easier to control the marketing if the company were dealing with just one distributor.

Obviously, however, calling on a national as a wholesale solution to

Workman connects tanks filled with solvents distributed by McKesson

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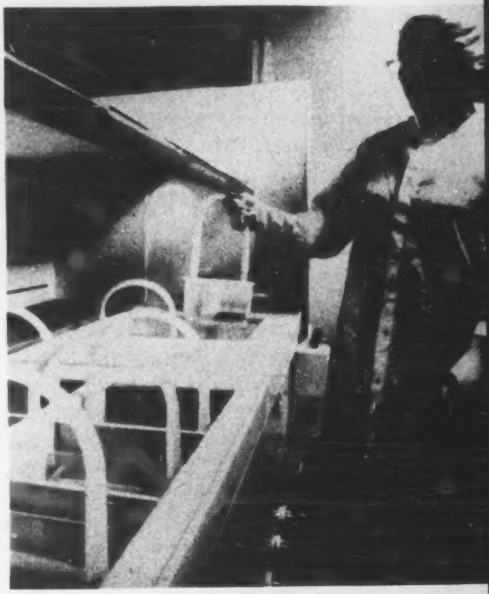
a distribution problem can work only in some cases. For the commodity-type product that must reach every corner of the U.S., says Du Pont's Cluett, the way to do it is through a national, because it has branches in many parts of the country.

Cluett points out, however, that both multilocation distributors and independents have their particular strengths. "Our distributor network is made up of both kinds," he says. "We don't look at them so much in terms of what strength they bring in general. We look at them in terms of what strength they bring to a particular marketing effort we're trying to pursue. We have some specialty type products that go to very limited markets that don't belong with the nationals. We have some independents that handle those products just beautifully."

Although small size does not necessarily hamper an independent's operational competitiveness, lack of financial resources can hurt it. As product liability suits become ever more prevalent, chemical producers want to be sure that their distributors are adequately insured. A producer wavering between an independent and a national might give its business to the national, all other things being equal.

The need for extensive product liability protection and regulation-driven capital outlays also could keep many of the very small distributors out of two adjunct businesses that are becoming extremely lucrative—waste disposal and solvent recycling. Although solvent recycling already existed, it was the passing of the Resource Conservation & Recovery Act of 1976 (modified in 1980) that has given both businesses a push.

Among distributors, McKesson is a leader in recycling with its two-year-old McKesson Envirosystems operation—part of the company's chemical group, which had $603 million in sales last year. Ashland, also in recycling, has been collecting toxic wastes from customers considered "small generators" for the past two years. When the company accumulates a truckload of waste, it transports it to Chemical Waste Management for disposal. By 1990, says Ashland's Parsons, waste disposal could account for as much as 10% of the company's business.



Silicon chip wafers are bathed in McKesson-supplied hydrofluoric acid

None of this means that the nationals are going to dominate chemical distribution. Their aggregate share of the market is still small, and some analysts believe it will not get significantly larger.

"The independents aren't going to disappear off the face of Earth by any means," says A. T. Kearney consultant Gunn. "They're there. I don't think the nationals are going to be able to gain share at the expense of the independents. I do think that the nationals will continue to pick up share that is marginally producer business now. There may be some erosion at certain localities where the national companies will pick up some share from the locals. And there also will be continued acquisitions."

Gunn points out that many small distribution firms were founded after World War II. Their founders, now nearing retirement age, can liquidate their investment by either passing the company on to employees or family members or selling out. Gunn sees "selective" sales of independent companies to both national and large regional distributors.

Continued acquisition of smaller companies would seem to indicate growing concentration of market share among fewer firms, but so far, at least, the number of companies disappearing by absorption has been more than matched by the creation of new firms.

PPG's Buerkle says: "My experience is that every time a national distributor acquires an independent, it seems like someone from the management group will go out and start another independent. I don't see any thinning out of the ranks. Things like product liability make mom and pop distributors almost impossible, but as old distributors disappear, either because of bankruptcy or by being purchased, another distributor will blossom in its place."

But consultant Gunn is not so sure. Between regulations and local zoning boards, he points out, it is difficult for a new company to get permits. It is also difficult to build a customer base now, he says. "Customers don't want to deal with more distributors," he says. "There are plenty of distributors out there right now. They've got to have a good reason for going to a new [one]."

To attract new customers, distributors both new and old are increasingly realigning their product lines to establish themselves in niches. Chemcentral, for example, despite its size, specializes in markets like protective coatings, printing inks, adhesives, chemical specialties, and rubber and plastic products. "Some people use a shotgun approach," says chief executive Hough. "We try to use a rifle approach."

Hough points out that not all distributors must choose a product niche. Some firms, he says, will get on very well with a shotgun approach. "It may be that some organizations will have both specialty salesmen and general line salesmen," he explains.

But Buerkle believes most distributors will have to specialize in the future. "The survivors are all going to end up, by hook or by crook, getting into one of these niches," he argues.

No one thinks chemical distributors will be able to prosper by standing still. In other words, the 1980s will bring them big growth but also major reshuffling. "[Distributors are] going to have to be in state-of-the-art distribution management techniques if [they're] going to survive later in this decade," says Great Lakes Terminal & Transport's Kendell. "We feel that closer touch to the customer is going to be very important, increased service is going to be very important, and probably most important will be the need to add to the product line those products or services that are value-added and that the distributor invests in rather than the manufacturer. That's going to be a tough bullet to bite for many distributors, because they do not have the kind of reserves necessary to support that kind of effort." □

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VISION

Chemistry that transforms light into sight
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CHEMICAL & ENGINEERING NEWS

NOVEMBER 28, 1983

News of the Week

- **OSHA issues final regulations on labeling hazardous chemicals in the workplace.** **Page 4**
- **Congress kills funding for binary chemical weapons.** **Page 5**
- **Researchers find way to channel intense beam of light through glass fiber.** **Page 5**
- **Quiet year predicted on the labor front in 1984, despite some major union negotiations.** **Page 5**

Business

American Hoechst earnings will be up markedly this year, largely because of general reorganization and streamlining moves. **Page 9**

International Business

U.S. trade balance in chemicals and other basic manufactures could get much worse because of disadvantage in labor costs. **Page 10**

Government

Superfund needs more money to continue cleanup procedures; chemical industry supports extension of 1985 deadline. **Page 15**

Data show a 7% drop in federal support for R&D from fiscal 1980 to fiscal 1981, confirming earlier predictions. **Page 16**

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National Science Board report presents a broad view of the extent and variety of university/industry research interactions. **Page 21**

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Shortage of qualified toxicologists prompts new programs offering bachelor degrees in toxicology. **Page 22**

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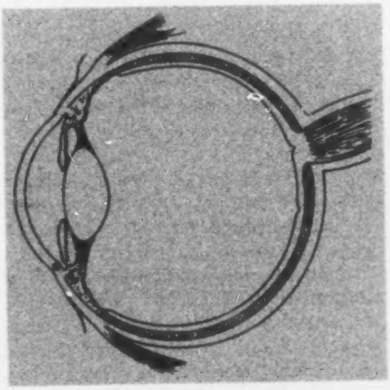
"Renewable Energy: The Power to Choose" by Daniel Deudney and Christopher Flavin documents accomplishments in the field. **Page 37**



Special Report

The process by which the eye transforms light into sight has scientists looking for clues at molecular level. **Page 24**

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Study Updates Academe/Industry Research

The possibility of universities tapping industrial research funds to support their own research projects has been getting a great deal of attention in the past few years.

Universities see it as a way to mitigate, in part, the consequences of severe cutbacks in federal research support, companies see it as a useful investment to help secure a future supply of high-quality scientific manpower, and the federal government sees it as an increasingly important factor in its efforts to assure continued U.S. pre-eminence in high-technology industries.

A comprehensive look at just where these cooperative efforts stand, in the form of a year-long study by Lois S. Peters, research associate, and Herbert I. Fusfeld, director, both of New York University's Center for Science & Technology Policy, has just been published by the National Science Board. The study was commissioned by NSB to serve as background material for its most recent annual report to Congress that focused on this issue. That report, issued last February, concluded that interactions between universities and industry to support research are vigorous, varied, and growing in importance (C&EN, Feb. 21, page 18).

The study presents a broad view of the extent and variety of current university/industry research interactions and tries to characterize the principal types, identify the factors that appear important in the formation of such interactions, and provide some perspective on the current state of university/industry interactions.

"The most successful interactions are almost always initiated and nurtured by a key individual who is energetic and has a belief that the success of this program is essential to his or her professional development," the study finds. Successful programs are much more likely to begin at the university, but not in the top levels of university administration. Often the university's endowment or other financial resources are critical to getting cooperative projects off the ground, since industry is much more apt to support an existing program than to participate in the creation of a new area of research at a university.

One key role that the government has sometimes played in successful university/industry cooperative programs is to catalyze this early funding, the study suggests. In several cases, such as Massachusetts Institute of Technology's Polymer Processing Center, a direct grant from the government supported the project in its initial stages.

The most important measurable "product" of university/industry cooperative research, especially from industry's point of view, usually is highly trained Ph.D. recipients, the study says. Graduates from these cooperative programs usually take jobs in industry, and as the number of cooperative programs grows, "there is the belief that the number of Ph.D.s oriented to an industrial career will increase, or at least new Ph.D.s will be better prepared to meet industrial needs," the study says. Cooperative programs that produce research results "directly related to technical change are rare, if they occur at all," it continues. However, the programs rarely are set up with this goal in mind. Particularly on the industrial side, "the interest is in students and access to new ideas rather than to a specific product, process, or service."

Although university/industry cooperation is flourishing in many senses, the report does not paint an entirely rosy picture of these interactions. Every university involved in the study cited conflicts over patenting arrangements and the related question of restrictions of information dissemination as a barrier to university/industry interaction.

Most common research interaction is cooperative research . . .

Type of interaction	% falling into that category
Cooperative research	61%
Technology transfer	14
Knowledge transfer	13
General research support	11
TOTAL	100%

. . . which can take many forms

Type of interaction	% falling into that category
Grants & contracts	45%
Cooperative research centers	25
Special interest liaison programs	23
Research consortia	5
Collaborative interactions	2
TOTAL	100%

Another difficulty, from the university's point of view, is that industrial support tends to come in small, short-term allotments on the order of $10,000 to $20,000 for one year or less. This leads some university scientists to focus their efforts to secure research funding on the federal government, which tends to give larger, longer-term grants. Most companies do not appear to be geared toward long-term commitments to basic research support.

Still another problem in many academic fields, including chemistry, is the psychological barrier academic scientists feel about interacting with industry. "The more basic the research, the greater the feeling is that industry will, in some way, impede the ability of the individual investigator to follow his or her own perceived optimal course," the study finds, even in fields like chemistry.

Copies of the study, entitled "University-Industry Research Relationships: Selected Studies," stock number 038-000-00534-1, are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $7.00 per copy. □

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Catalysts

Steady growth ahead

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Cover: Catalyst feed material exits from the primary heat circuit at Engelhard's McIntyre, Ga., plant

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CHEMICAL & ENGINEERING
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DECEMBER 5, 1983

News of the Week

- **Presidential science adviser Keyworth names deputy director, five assistant directors for White House OSTP.** Page 6
- **U.S. chemical industry spending for R&D in 1984 will increase 11% over the 1983 level, NSF survey indicates.** Page 7
- **Current space shuttle mission carries heaviest scientific payload to date.** Page 7
- **Harvard University receives patent rights to genetic engineering process to make proteins.** Page 7

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Business

Catalysts constitute a profitable industry and products for the petroleum refining, automotive, and chemical areas are expected to enjoy a combined 3% annual growth through 1987. **Page 19**

Government

In its final session, Congress passed agency appropriation bills, but postponed bills on natural gas prices, pesticides. **Page 32**

Science

Spacelab 1 aboard the space shuttle will be used to conduct more than 70 experiments in five scientific research areas. **Page 40**

Technology

Administration's expansion of the U.S. Exclusive Economic Zone will aid prospective miners if economics are favorable. **Page 47**

Books

The evolution of AIChE and its contributions are traced in "75 Years of Progress—a History of the American Institute of Chemical Engineers 1908–1983" by Terry S. Reynolds. **Page 56**

News Focus

Edward E. David, former science adviser to President Nixon, says current Administration is getting effective advice, discusses federal role in innovation. Page 9

Catalysts: a Chemical Market Poised for Growth

Moving up steadily from sales base of $1.3 billion, catalysts are good business but demand heavy outlays for development and service

Stephen C. Stinson, C&EN New York

Continued recovery of the U.S. economy is bringing renewed, if sometimes uneven, growth to catalysts used by various industries. Catalyst use in the U.S. could top 4.7 billion lb this year, worth about $1.3 billion, up 3% from last year.

Among the three principal industries that use catalysts, petroleum refining is the largest. It might consume 4% more catalysts this year than in 1982, bringing the total to 4.5 billion lb, valued at $530 million. Of this, however, 4.1 billion lb will be low-price, commodity sulfuric and hydrofluoric acid alkylation catalysts, some on solid support and some not, amounting to only $165 million. The chemical industry may raise its use 4% to 210 million lb, valued at $485 million. Automotive and industrial emission control catalysts could reach a value of $325 million, down 3% from 1982.

Overall, the catalyst business is a good one to be in, according to analyst Bruce W. Deckman of Strategic Analysis, Reading, Pa., business consultants to the chemical, mineral, metal, and allied industries. One reason he cites is its large size, well over $1 billion. A second reason is the relatively modest but steady 3% annual growth he predicts for catalyst volumes through 1987. Third, catalysts are very profitable products in general, he says, whose development is based on sophisticated technology and whose marketing depends on skilled technical service. Thus, firms who can acquire such expertise find catalysts attractive specialties to enter.

Indeed, acquisition of existing suppliers or personnel is the preferred route into the business, Deckman says, because of technological requirements as well as the close personal contacts and track record of success elsewhere needed to sell to conservative customers. One recent newcomer, Katalistiks of Baltimore, seems to prove the rule. Originally founded in Amsterdam as a joint venture among Catalyst Recovery International of Baltimore, EKA of Göteburg, Sweden, and English China Clays of St. Austell, England, the firm established a U.S. subsidiary in 1982. Katalistiks specializes in fluid cracking catalysts for petroleum refining. The company's first move was to hire many management, research, technical service, and sales people from competitors. The firm depended on imports from its Delfzijl, the Netherlands, plant for a year. Then, a 130 million lb-per-year plant opened in Savannah, Ga., in June 1983.

Monolithic catalyst made by Engelhard can remove industrial exhaust contaminants and paint fumes

A second new organization, Harshaw/Filtrol Partnership, headquartered in Cleveland, is a joint venture founded in November by combination of Kaiser Aluminum & Chemical's Filtrol Corp. and Gulf Oil's Harshaw Chemical Corp. Filtrol made catalytic cracking, hydrotreating, and hydrocracking catalysts. Harshaw produced hydrotreating and hydrocracking catalysts, as well as those for chemical production. The move satisfied a desire by Gulf managers to get out of specialty chemicals and concentrate on their commodity chemicals and oil business.

Twenty-six firms are major suppliers of catalysts

Supplier	Petroleum refining					Chemical processes							Emission control
Abbott Laboratories						●							
Activated Metals									●				
Air Products		●			●	●			●				
Akzo Chemie America Catalyst division		●											
Noury Chemical						●							
American Cyanamid		●		●	●		●						
Calsicat[a]						●		●	●				
Catalyst Resources[b]						●							
Davison[c]	●					●	●		●				
Engelhard	●				●		●	●					●
Ethyl						●							
Halcon							●						
Haldor Topsoe										●	●		
Harshaw/Filtrol[d]	●	●		●			●		●				
Johnson Matthey							●	●					●
Katalco[e]		●								●	●		
Katalistiks	●												
Lucidol[f]						●							
M&T Chemicals[g]						●							
Monsanto							●						
Shell Chemical		●		●			●					●	
Stauffer Chemical			●			●	●						
Texas Alkyls[h]						●							
UOP[i]		●		●	●			●					●
Union Carbide						●	●						
United Catalysts							●	●	●	●	●	●	
Witco Chemical Organics division						●							
Pearsall Chemical								●					
U.S. Peroxygen						●							

Key:

- ● = Catalytic cracking
- ● = Hydrotreating
- ● = Alkylation
- ● = Hydrocracking
- ● = Catalytic reforming
- ● = Polymerization
- ● = Oxidation, ammoxidation, and oxychlorination
- ● = Organic synthesis
- ● = Hydrogenation
- ● = Steam reforming
- ● = Ammonia and methanol synthesis
- ● = Dehydrogenation

[a] Division of Mallinckrodt. [b] Division of Phillips Chemical. [c] Division of W. R. Grace. [d] Joint venture of Gulf Oil and Kaiser Aluminum & Chemical. [e] Joint venture of Nalco Chemical and Imperial Chemical Industries. [f] Division of Pennwalt. [g] Subsidiary of Elf-Aquitaine. [h] Joint venture of Hercules and Stauffer Chemical. [i] Subsidiary of Signal. **Source:** Strategic Analysis

Kaiser has six years to decide whether it will buy out Gulf's share.

But for all the attractions of catalysts, Deckman of Strategic Analysis advises caution to those who would enter the business. First, catalysts are cyclical, depending as they do on levels of activity in the oil, chemical, and automotive industries. Also, changes in energy costs and technological developments have definite impacts on specific products. And catalyst producers are susceptible to occasional materials shortages and wide price swings in raw materials.

For example, according to Bureau of Mines reports, disorders in Zaire in 1978 led to disruption of copper mining there, of which the catalytically important metal cobalt is a by-product. Cobalt had not been mined in the U.S. since 1971. A U.S. cobalt refiner put customers on 70% allocation for two years. During the period, prices rocketed to $25 per lb from $6.40, with spot sales at $45.

On the other hand, rhenium is an example of a raw material whose price and supply have depended on technological development and government regulations. Platinum and rhenium on a support become a so-called bimetallic reforming catalyst that can allow far more production than platinum used alone—the practice before bimetallics were developed. Catalytic reforming is a process that increases amounts of octane-improving aromatics and olefins in a hydrocarbon stream. Bimetallic catalysts had been under study at refineries all through the 1970s. But when the full effects of the phaseout of lead additives in gasoline began to take hold in 1979, that plus the temporary gas shortages of that year drove refiners to order large amounts of bimetallic catalyst. The price of rhenium soared to $2500 per lb from $350 by mid-1980. Thereafter, economic recession, imports, and increased efforts of U.S. molybdenite roasters to recover by-product rhenium restored the supply/demand balance.

But if such external factors as government regulations can give catalyst producers raw material supply and price headaches, they also can give birth to whole new profitable businesses. The Clean Air Act of 1970 gave birth to the automotive emission control catalyst business, starting with the 1975 model year. Today, catalyst sales to the U.S. auto industry alone account for one fourth of catalyst industry sales. Principal suppliers of this catalyst type are American Cyanamid, the Davison division of W. R. Grace & Co., Engelhard Corp., Johnson Matthey, and UOP.

Through the years, there has been a slow evolution away from pelleted automotive catalysts in the direction of monolithic types, originally invented by Engelhard's Carl D. Keith, who is now executive vice president. Monoliths are blocks of porous ceramic with honeycomb structures, coated on the interiors with a wash of precious metal solution. This type finds increasing favor because its greater surface area per pound requires only a 2-lb block, in contrast with the 7 to 8 lb of alumina pellets needed to accomplish the same effect in a catalytic converter. This has saved space, weight, and cost of precious metals, especially since 1978, as emissions standards tightened and pellet-containing converters got larger in the face of a trend toward smaller cars.

American Cyanamid and Davison sell pellets, which General Motors still may use in less than half of its production. Engelhard supplies both pellets and monolith. Johnson Matthey makes only monolith.

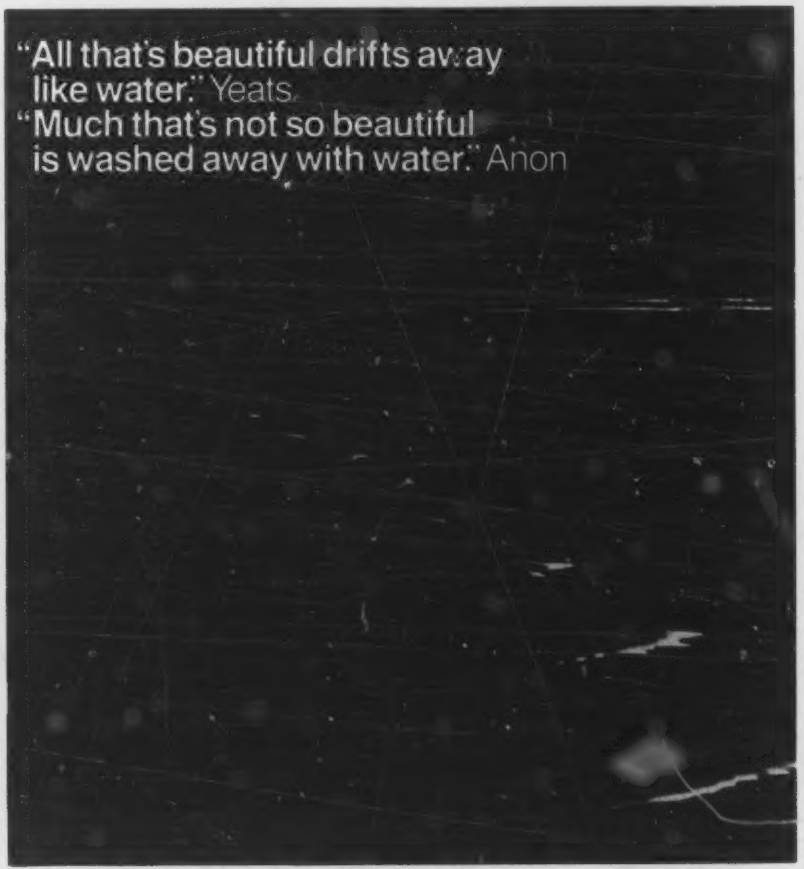
But pellet makers have not been idle. One of those confident of reversing the trend is Don McCulloch, who is both technical director of Cyanamid's catalyst department (refinery and chemical production catalysts) and general manager of Catalyst Co. (automotive catalysts), a joint venture with Japan Catalytic. Catalyst Co. has developed a new, less costly process for pellet production that involves fewer impregnation, drying, and calcination steps. These new catalysts are in trial at General Motors, where truck engine converters are among those that may not need space and weight savings of monoliths.

In addition to a trend toward monolithic automotive catalysts, increasingly stringent nitrogen oxide emission regulations have sparked a move toward dual-bed converters. In this system, a platinum-rhodium catalyst processes an oxygen-lean exhaust gas to reduce nitrogen oxides to nitrogen. After air injection, the gas passes to a conventional platinum-palladium catalyst for oxidation of carbon monoxide and hydrocarbons.

Development of dual-bed converters again was pioneered by Keith of Engelhard, whose work won Engelhard awards from the U.S. Council on Environmental Quality and the United Nations. Such converters in use today may be either two units in sequence or one unit with two catalyst beds within it. The next step in catalytic converters may be a return to a single unit with a single catalyst type, Keith says, with a resulting cost savings. He notes that this type is already available in some European imports. Keith cautions that introduction of single-catalyst converters by U.S. auto makers will depend on catalyst research and improvement of controls by car makers. The eventual catalyst for this next generation may be platinum-rhodium, platinum-palladium-rhodium, or some formulation that includes other metals, he says.

The rise in consumption of precious metals for the new application of auto catalytic converters has given birth to a new industry that recovers those metals. Recovery of precious metals from petroleum refining and chemical production catalysts has long been the norm. Recovery from converters poses special problems of rounding up large numbers of scrapped units and separating the relatively small amounts of precious metals they contain.

Two firms that have solved these problems are Gemini Industries, Santa Ana, Calif., and Johnson Matthey. J. P. Rosso, assistant to the president at Gemini, says that his company began missionary work among automobile junkyards by giv-


"All that's beautiful drifts away
like water." Yeats
"Much that's not so beautiful
is washed away with water." Anon

CIRCLE 6 ON READER SERVICE CARD

Chemical industry uses wide variety of catalyst types

Selected processes	Products	Major catalysts used
POLYMERIZATION		
Ethylene, propylene	High-density polyethylene, polypropylene	Trialkylaluminums and titanium(IV) halides (Ziegler-Natta types)
Ethylene, vinyl chloride, styrene	Low-density polyethylene, polyvinyl chloride, polystyrene	Organic peroxides
SYNTHESIS GAS		
Steam hydrocarbon reforming	Hydrogen and carbon monoxide	Nickel on alumina with potassium oxide promoter
Ammonia synthesis	Ammonia	Ferric, aluminum, and calcium oxide with potassium oxide promoter
Methanol synthesis	Methanol	Combinations of aluminum, chromium(III), cupric and/or zinc oxides
Olefins	Aldehydes	Cobalt, rhodium, or ruthenium complexes with carbon monoxide, amines, or phosphines
Acetic acid	Acetic anhydride	Iodine and complexes of rhodium with carbon monoxide and phosphines
ALKYLATION		
Benzene	Cumene	Phosphoric acid on silica
Benzene	Detergent alkylates	Aluminum chloride, fluoboric acid, or hydrogen fluoride
Benzene	Ethylbenzene	Alumina and silica or phosphoric acid on silica
HYDROGENATION		
Benzene	Cyclohexane	Nickel or platinum on alumina with lithium oxide promoter
DEHYDROGENATION		
Butane	Butadiene	Chromium(III) and aluminum oxides
Butene	Butadiene	Calcium and nickel phosphates; ferric and aluminum oxides; or ferric and chromium(III) oxides
Ethylbenzene	Styrene	Ferric oxide with chromium(III) and potassium oxide promoters
Petroleum hydrocarbons	Benzene, toluene, and xylenes	Platinum and rhenium on silica and alumina
OXIDATION		
Ammonia	Nitric acid	Platinum-rhodium gauze
Ethylene	Ethylene oxide	Silver on alumina with cesium oxide promoter
Methanol	Formaldehyde	Copper or silver, as gauze or on support; or ferric and molybdic oxides
Propylene	Propylene oxide	Molybdenum, vanadium, or titanium naphthenates
Sulfur dioxide	Sulfur trioxide	Vanadium pentoxide
AMMOXIDATION		
Methane	Hydrogen cyanide	Platinum-rhodium, as gauze or on support; or platinum, ruthenium, or aluminum on ceramic support
Propylene	Acrylonitrile	Uranyl antimonate
OXYCHLORINATION		
Ethylene	Ethylene dichloride	Cupric chloride on support

Sources: Charles H. Kline & Co., SRI International, and K. Weissermel & H.-J. Arpe, "Industrial Organic Chemistry"

ing talks to and advertising in publications of the Automotive Dismantlers & Recyclers Association and the National Association of Recycling Industries. Auto scrappers already were required by law to remove gas tanks before junking, and Gemini spokesmen pointed out to them that it would take only 15 seconds more to cut out the converters. In addition, Rosso says, when the price of platinum hit $985 per troy ounce in 1980, middlemen sprang up all over the U.S. to organize converter collection in their areas, break them up in regional warehouses, and ship the drummed contents to Gemini. Sale prices for converters reached $12 at that time, but have since subsided to $4.00, owing to lower platinum prices. Rosso says that it takes a platinum price of $400 to $450 per ounce to encourage large-scale converter shipments to his firm. Gemini recovers palladium and rhodium as well as platinum and accepts monolith as well as pellet supports.

Among all catalyst makers, three that produce for the auto industry—Cyanamid, Davison, and Engelhard—are the only ones that span the two other major user industries: chemicals and petroleum. Such specialization also is typical for catalyst producers who aim at a target industry, Deckman of Strategic Analysis points out. In the oil industry, for example, Cyanamid supplies catalysts only for hydrotreating, hydrocracking, and reforming, Davison for cracking, and Engelhard for cracking and reforming. This kind of specialization also occurs by process. Most needs for catalytic cracking, reforming, and hydrocracking are served by only four firms, for example, and the four are not the same for each process. Just six companies account for most sales to hydrotreating, the fastest-growing refining catalyst market.

Hydrotreating and the catalysts it uses will grow 5% annually at U.S. refineries through 1987, Deckman says. This is because of the need for refiners in coming years to process heavier crudes, containing larger amounts of sulfur and nitrogen. Growth might have been even higher, he says, but for the current oversupply of oil and consequent

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accessibility of lighter crudes. This condition caused many refiners to delay installation of units to treat residual oil, each one of which takes large amounts of catalyst just to fill it for the first time.

Cyanamid is thought to have the largest market share of hydrotreating catalysts, followed by Akzo Chemie America, Shell Chemical, and Katalco. Competition is rife in this market, owing mainly to a year-long push by Shell Chemical in all its refining catalysts. As catalyst department manager Brian A. Turner tells it, the firm increased its development efforts, capitalizing on technology it had, to bring out new products. Shell Chemical also doubled its catalyst sales force, bringing in people with product development and refinery management experience, who could best show customers how to get results.

Shell Chemical's catalyst department has the advantage of cooperation from its parent's refineries to try out new catalysts. This is important to carry field experience to customer prospects outside Shell. But a catalyst producer need not be owned by an oil company. Engelhard has a close relationship with Atlantic Richfield that allows the firm to get needed refinery operating data, says John R. Gilmore, Engelhard's senior product manager for reforming catalysts.

Both Harshaw and Filtrol were makers of hydrotreating catalysts separately, and some observers say that their combined forces could someday make them a much bigger power there. Others note, however, that neither was ever a very big factor in hydrotreating catalysts, and that together they hold no more than 10% of the market.

Whereas hydrotreating cleans up refinery streams for other processes, hydrocracking converts heavy feeds to high-quality middle distillates for such uses as diesel and jet fuel. Hydrocracking is expensive, however. Catalysts are about $20 per lb, and hydrogen, when not available in sufficient amounts from reforming, must be made by steam reforming of naphtha. Nevertheless, hydrocracking has found roles at refineries.

Cyanamid's McCulloch comments that the hydrocracking process is cost-effective whenever there is a market for the diesel-type output, whose low aromatics content suits it to this use. Turner of Shell Chemical says there is an advantage in the versatility of hydrocracking in accepting heavier feeds.

Though hydrocracking has found its niche at refineries, fluid catalyt-

Catalyst consumption will grow 5% annually

	1982		1987	
Consumption[a]	Millions of lb	$ Millions (constant)	Millions of lb	$ Millions (constant)
PETROLEUM REFINING	4377	$ 510	5113	$ 620
Catalytic cracking	350	235	445	330
Alkylation	4000	150	4635	170
Hydrotreating	21	65	27	85
Hydrocracking	2	40	2	45
Catalytic reforming	4	20	4	20
CHEMICAL PROCESSES	200	465	248	570
Polymerization	65	215	83	270
Organic synthesis	90	80	110	95
Oxidation, ammoxidation, and oxychlorination	10	75	12	90
Hydrogen, ammonia, and methanol synthesis	23	50	28	60
Hydrogenation	8	35	10	42
Dehydrogenation	4	10	5	13
EMISSION CONTROL	na	333	na	297
Automotive	na	330	na	285
Industrial	na	3	na	12
TOTAL	4577[b]	$1308	5361[b]	$1487

a Includes captive use. b Emission control poundage not included, as figures not compiled. na = not available. Source: Strategic Analysis

ORGANIC INTERMEDIATES FROM SWITZERLAND

for
- dyestuffs
- pharmaceuticals
- agrochemicals
- perfumes
- flavours
- photochemicals

3-Nitro-o-toluic acid
and other isomers
COOH, CH_3, NO_2

2,4-Xylidine
and all other isomers
NH_2, CH_3, CH_3

1-Chloro-3,4-dinitrobenzene
Cl, NO_2, NO_2

5-Chloro-2-nitrobenzoic acid
and other isomers
COOH, NO_2, Cl

2,3-Dimethyl-6-nitroaniline
6-Nitro-2,3-xylidine
NEW
NH_2, NO_2, CH_3, CH_3

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ic cracking (FCC) is still the far more important process, because it converts heavy feeds to lighter product suitable for gasoline. Paul J. Norris, Engelhard's petroleum catalyst marketing director, expects use of FCC catalysts to grow moderately this decade, owing to increased processing of residual oil, countered by current excess U.S. refining capacity. Before building new cracking units, Norris explains, refiners can use their currently idle cracking capacity.

For the future, Norris expects development of FCC catalysts to progress toward specialized types. These specialized types will have unique abilities to solve such problems as refining residual, high-nitrogen, or high-sulfur gas oils, or to resist attrition in crackers.

A shakeup in current FCC market structure is sure to come as a result of the entry of Katalistiks. Company president Regius Lippert claims the firm already has garnered 10% of the U.S. market. Offering a very low price for trial periods, Katalistiks got orders to supply replacement catalyst to half a dozen units. Because catalyst attrition can reach up to 4% per day in units cracking residual oil, as little as 25 days were needed to replace all the catalyst to judge performance of Katalistiks' product alone.

Besides catalytic cracking, reforming is another process used to make gasoline. About 75% of U.S. refining has switched to platinum-rhenium reforming catalysts, estimates Gilmore of Engelhard, because of the longer catalyst life compared to one year for types that were used previously.

Gilmore predicts that penetration will reach 90% in this decade, owing to replacement of old reformers with new ones that operate under more severe conditions. Increasing severity of reforming increases the aromatics content of the reformate needed for high-octane gasoline, but also lowers yield and shortens lifetimes of other catalysts. Gilmore expects demand for reforming catalysts to increase slightly, because of decreased gasoline demand, offset by increasing need to use aromatics content to replace the declining use of lead, as well as increased offerings of unleaded premium gasolines.

In addition to the auto and refining industries, chemical and plastic resin production also requires a large volume of catalysts. Process and therefore catalyst types are much more numerous in making chemicals and resins than in refining. And whereas the platinum-rhenium catalyst is the only recent breakthrough in refining, chemicals and resins depend on continuous quantum jumps in catalyst development. This has been especially true since 1973, when concerns over energy and feedstock shortages triggered a push toward lower process pressures and temperatures, elimination of intermediates, and use of such alternative raw materials as carbon monoxide and hydrogen.

For example, Tennessee Eastman will use rhodium catalysts at its Kingsport, Tenn., acetic anhydride plant, developed by itself and Halcon International, for a series of processes that begin with carbon monoxide and hydrogen from coal gasification. Halcon has invented similar catalysts for vinyl acetate production. Union Carbide also is working on a rhodium catalyst to make ethylene glycol from synthesis gas, bypassing ethylene and ethylene oxide.

Economic feasibility of the Carbide process will depend on what further improvements such companies as Shell Chemical can make in catalysts for direct oxidation of ethylene to ethylene oxide. During the 1970s, Shell and other firms pushed yields past 80% from 70%, thus making direct oxidation increasingly attractive.

Carbide, Dow Chemical, and Du Pont have developed proprietary catalysts to copolymerize ethylene with small amounts of such olefins as 1-butene to produce linear low-density polyethylene. This technology, which produces a superior product and saves on energy and capital investment costs, has since been extended by Carbide to polypropylene. Not to be outdone, Italy's Montedison has perfected a polypropylene catalyst that likewise saves energy and costs of removing catalyst residues and atactic polypropylene. □

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DECEMBER 12, 1983

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Chemical capital spending finally rebounds

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CHEMICAL & ENGINEERING NEWS

DECEMBER 12, 1983

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- **Visitors to the biennial Chem Show in New York City were in a buying mood. Page 4**
- **Mobay Chemical's newly developed polycarbonate resin can be molded 15% faster than standard grades. Page 5**
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Zero-field NMR enhances interpretation of complex spectra; ion detection increases Raman sensitivity; oxygen monitor will be used to study fate of carbon dioxide in the atmosphere. **Page 23**

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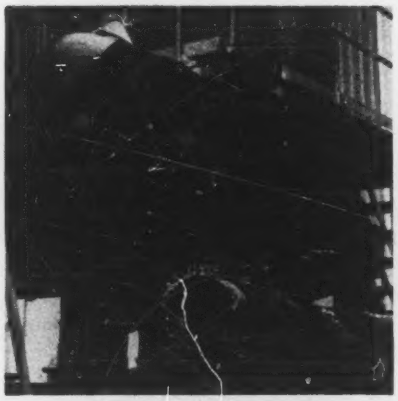
Society's Committee on Professional Relations reports on 19 mass terminations of chemists and chemical engineers. **Page 27**

Meetings

35th Pittsburgh Conference on Analytical Chemistry & Applied Spectroscopy will be held in Atlantic City March 5-9. **Page 31**

C&EN's semiannual calendar of events lists meetings of interest to chemists and chemical engineers during 1984. **Page 37**



Cover Story

U.S. chemical capital spending will rise 14% in 1984, a significant recovery from the drastic 1983 decline. Page 10

Chemical Capital Spending Starts To Rebound

Expenditures by major U.S. chemical firms are slated to rise 14% in 1984 following big drop this year, but still will be below 1982 level

William J. Storck, C&EN New York

Turnaround time finally has arrived in the U.S. basic chemical industry for capital spending, its largest use of funds after ordinary running expenses and taxes. This future-oriented investment in new plant and equipment is on its way up again in 1984 after the worst drubbing in recent decades.

Rebounding perhaps a bit earlier than many industrial analysts would have suspected a year ago, capital spending has to rise now as chemical companies use up spare plant capacity and build up larger than expected cash flows (earnings plus depreciation). This means that the first relief is in sight for hard-pressed suppliers of chemical equipment and engineering and construction services.

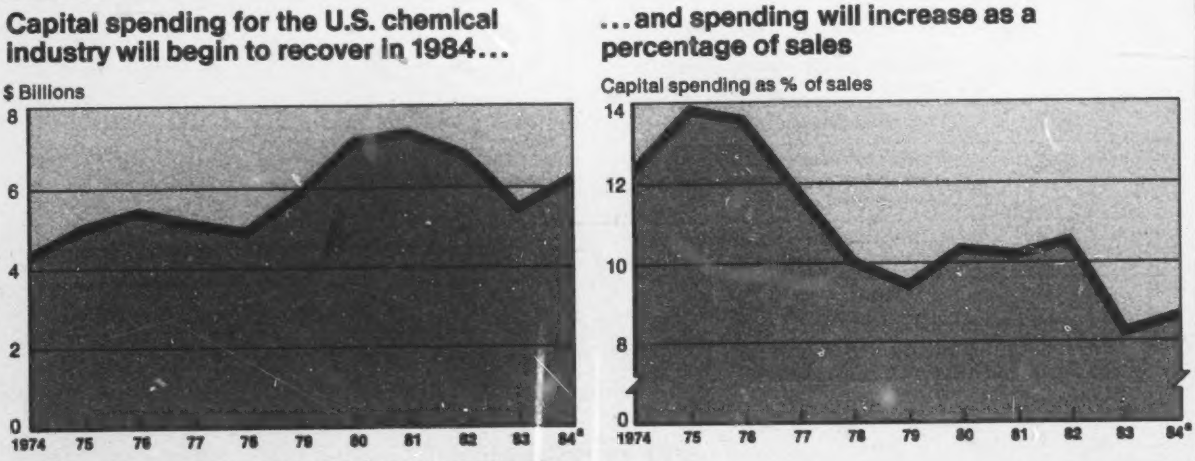
Specifically, C&EN's annual survey of capital spending budgets at leading U.S. basic chemical firms finds a 14% gain in store for 1984 after a worse than expected 23% drop in 1983. The resurgence is widespread, touching most producers.

The decline in 1983 should come as no surprise. Weak earnings forced many chemical producers to cut back on expenditures. Of course, the same situation that brought about the poor financial performance—lack of demand for chemical products—also alleviated the need for large infusions of capital investment during 1983 to build production facilities.

According to the Federal Reserve Board, seasonally adjusted chemical capacity use still is hovering in the low 70% range, up from 65% a year ago, in spite of a chemical production recovery under way since November 1982. With almost 30% of chemical plant capacity still idle, there has been very little need for chemical companies to build new plants. In fact, it seems that most plant expansions in the past year or more came about from efforts to boost efficiencies and capacity increases through new process developments rather than through new facilities.

Then, too, interest rates and the cost of capital have been higher than the possible return on investment that companies could hope to get from many new chemical projects. Although interest rates may ease somewhat in early 1984, many economists see interest rates trending back upwards later in the year. Thus, companies may have a small window early next year in which to go to the market for debt, but unless returns increase substantially, even this may not help the capital spending situation very much.

The slight rebound in capital spending is not limited to the chemical industry. Wharton Econometric Forecasting Associates, Philadelphia, says that business fixed investment spending is beginning to rise and will lead the economy upward in 1984. Wharton says, however, that the length and depth of the reces-



Capital spending for the U.S. chemical industry will begin to recover in 1984...

...and spending will increase as a percentage of sales

a C&EN estimate. Source: Combined data from major chemical companies

Chemical capital spending will rise to $5.37 billion for major firms

$ Millions	1984		1983		Worldwide					Change from previous year	
	World	U.S.	World	U.S.	1983 Planned[a]	1982	1981	1980	1979	1984	1983
Air Products	$ 300	$ 250	$ 246	$ 213	$ 275	$ 347	$ 323	$ 364	$ 246	22.0%	−29.1%
American Cyanamid	na	na	na	na	190	171	181	196	235	na	na
Celanese	na	na	na	na	110	275	414	253	245	na	na
Dow Chemical	750	400	600	320	750	829	1176	1184	1268	25.0	−27.6
Du Pont[b]	1500[c]	na	1276[c]	na	1100	1300	1420	1297	864	17.2	−1.8
Ethyl	95	90	80	75	100	92	141	156	123	18.8	−13.0
W. R. Grace	450	365	375	322	495	560	657	658	514	20.0	−33.0
Hercules	200	160	175	140	200	165	167	229	186	14.3	6.1
Monsanto	600	552	550	506	700	673	668	781	566	9.1	−18.3
Olin	175	170	130	126	160	139	186	172	161	34.6	−6.5
PPG Industries	400	na	400	na	400	452	376	401	252	0.0	−11.5
Pennwalt	na	na	na	na	na	77	53	53	66	na	na
Rohm & Haas	na	na	75	60	85	126	182	93	68	na	−40.5
Stauffer Chemical	130	110	104	96	170	177	239	246	239	25.0	−41.2
Union Carbide	775[c]	540[c]	770	539	950	1179	1186	1129	831	0.6	−34.7
TOTAL	**$5371**	**$2637**	**$4781**	**$2397**	**$5685**	**$6562**	**$7369**	**$7212**	**$5864**		
ANNUAL CHANGE[d]	**14.1%**	**12.8%**	**−22.6%**	**−27.1%**	**−11.8%**	**−11.0%**	**2.2%**	**23.0%**	**18.9%**		

a Earliest estimates. b Excludes Conoco. c C&EN estimates. d Cumulative change for companies reporting. na = not available.

sion have left their mark on investment spending.

If such a scar remains on capital spending, it may be that companies will be more cautious in the future about committing funds to capital projects. Besides the recession, higher interest rates, a generally slower chemical economy, and a new import threat may reinforce this caution. If this does indeed come about, it will help prevent what many industry analysts see as one of the great sins of the past in the industry—the overexpansion in basic chemical products, many of which have become only marginally profitable.

Therefore, it may be a long time before the chemical industry increases its capital spending at the 20 to 25% per year clip that was typical in the late 1970s.

For 1983, the bottom fell out in new plant investment. Combined capital spending for 12 of 15 companies surveyed by C&EN (those giving consistent data) declined 22.6% from 1982 to about $4.78 billion. Originally, chemical companies had planned to spend about 12% less than in 1982. However, as the financial aftermath of the 1982 recession deepened during this year's first two quarters, most companies clamped down on capital spending plans.

One of the big surprises, however, is that domestic spending by chemical companies dropped faster in 1983 than did total capital spending—indicating that overseas spending was not cut so much as was domestic spending. Whereas total capital spending by the companies responding dropped 22.6%, capital spending in the U.S. fell by a much greater 27.1%.

Of the companies surveyed, the biggest percentage drops in capital spending in 1983 from 1982 were at Stauffer Chemical, whose spending fell 41.2% to $104 million, and at Rohm & Haas, whose investment in plant and equipment fell 40.5% to $75 million. These were followed by an almost 35% decrease for Union Carbide to about $770 million.

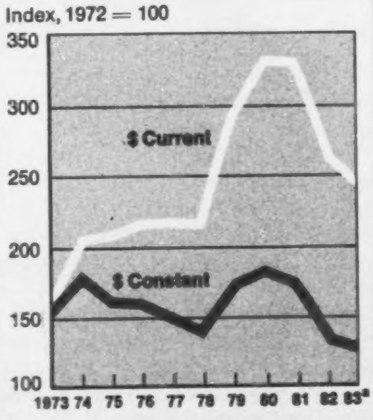
Air Products lowered its capital spending a little more than 29% from last year to $246 million. And Dow Chemical cut spending almost 28% to about $600 million. Dow's capital spending thus has dropped to less than half its 1979 level of $1.27 billion.

Monsanto's capital spending fell 18.3% this year to about $550 million, and Ethyl, which had the largest decline among the companies surveyed last year, sliced spending 13% to $80 million in 1983.

Only one company, Hercules, increased its capital spending in 1983 over last year—a 6.1% gain to $175 million.

The outlook for next year among U.S. chemical companies is a reverse of 1983, although capital expenditures will not regain their 1982 levels. Surveyed firms indicate that capital spending next year will increase 14% over 1983 to $5.37 billion. For those firms that break out foreign and domestic spending, such spending within the U.S. will rise about 13% to $2.64 billion.

Capital appropriations still down for chemical industry



a C&EN estimate. **Source:** Conference Board

Typical of capital projects this year is PPG's modernization at Lake Charles, La., chlorine-caustic plant

The largest increase next year reported so far is at Olin, which plans a nearly 35% boost in capital spending to $175 million. Among other companies slating pickups, Dow plans a 25% increase to $750 million, and Air Products plans a 22% gain to $300 million. W. R. Grace also plans a 20% increase to $450 million, Ethyl is budgeting a nearly 19% boost to $95 million, and Du Pont (according to C&EN estimates) likely will increase its chemical spending about 17% to almost $1.5 billion.

Only two companies, Union Carbide and PPG Industries, are not scheduling large increases in capital spending for 1984. Both are planning to keep investment spending for next year about the same as in 1983.

U.S. chemical companies likely won't have much trouble financing the increase in capital spending next year. In spite of still high interest rates, many of them have shelf registrations (large debt packages filed in advance with the federal government) that they can use when convenient. However, these may not be necessary, since most companies will be able to finance capital needs out of internal cash flow or new stock and will not have to borrow at all. ☐

Laser market due to triple by 1987

From a standing start in the 1960s, the intense light beams called lasers grew quickly into a broad-based U.S. business in the 1970s. But the fastest growth is still to come, say consultants Predicasts of Cleveland in a new report. The 1980s are expected to be a scintillating decade for lasers (light amplification by stimulated emission of radiation), more than tripling their 1982 market value in current dollars to $665 million in 1987. Growth will be across the board, touching all major types and markets (excluding military applications).

From 1982 through 1987, laser sales growth will average an eye-catching 26% per year, Predicasts predicts—slightly faster than the average 23% pace over the previous decade, when sales shot from $26 million in 1972 to $210 million in 1982. After 1987, sales growth will throttle down to 11% per year to push the total to $1.58 billion in 1995. Compared to U.S. economic growth, the 1990s laser clip will come close to the rate for current-dollar gross national product after running two and a half times that rate in the 1980s.

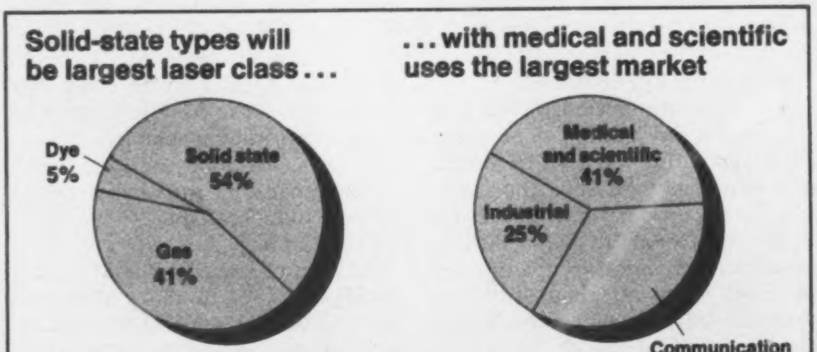
Behind such enviable prospects are massive market penetrations due for major laser types. The big gainer among the three major markets will be the medical and scientific area, where lasers with their capabilities in bloodless surgery are expected to play an increasing role in the fight against cancer. Predicasts says this market will grow 31% per year from 1982 through 1987, from $70 million to $275 million.

Not far behind medical uses in growth will be communications, currently the largest market with $80 million sales in 1982. Average jumps of 23% per year will put this market at $225 million in 1987, the report estimates. The main applications here are diode lasers in fiber-optic communications such as new telephone lines, and helium neon lasers in reprographics and printing.

The third principal market, industrial processing uses, was crimped by the three recent stop-and-go recession years. As a result, its average annual growth rate for the past decade lagged the other two major markets. But for the half-decade after 1982, Predicasts says annual growth will rebound to 22%, pushing sales from $60 million to $165 million. Typical uses include welding, drilling, cutting, heat-treating annealing, and lithography.

Amid such market strength, all major laser types—solid state, gas, and dye—are due solid gains, Predicasts finds. Best growth over the next five years will be for the solid-state group, which will take over the lead by 1987 after 32% average annual growth to $360 million in sales. The major push here will come from the communications market.

For the other two laser types, Predicasts estimates that sales of the gas group will shoot up 20% per year to reach $275 million in 1987, and dye lasers up 25% annually to $30 million. Helping gas lasers will be the medical market. Dye lasers will find their main use in testing and measurement. ☐



Source: Predicasts

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DECEMBER 19, 1983

CHEMICAL & ENGINEERING NEWS

World Chemical Outlook

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Cover: Dow Canada's Ft. Saskatchewan, Alta., ethylene derivatives and chlor-alkalies complex

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CHEMICAL & ENGINEERING
NEWS
DECEMBER 19, 1983

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- **New graduates will be in greater demand next year, according to the Northwestern Endicott Report.** Page 5
- **Chemical Manufacturers Association forecasts strong 1984 for chemical industry.** Page 5

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Science

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Technology

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Chemical-containing rockets fired into ionosphere in attempts to improve satellite communications. **Page 21**

Special Report

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Job outlook for spring grads is looking good

Good news for next spring's college graduates: More jobs. According to Northwestern University's 1984 Northwestern Endicott Report, an annual survey of employers' hiring intentions, major U.S. companies expect to hire about 20% more graduates with bachelor's degrees and 28% more with master's degrees than in 1983. Starting salaries will increase, but only modestly, says Victor L. Lindquist, Northwestern's director of placement.

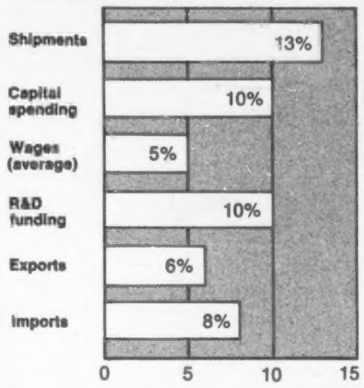
Demand for new bachelor-level graduates is projected to rise 21% for engineers, 28% for computer scientists, 31% for chemists, 25% for accountants, 28% for business administration majors, and 10% for sales/marketing majors. But three fields show decreases in demand, compared to 1983: liberal arts, down 15%; mathematics/statistics, down 17%; and economics/finance, down 5%.

As for graduates with master's degrees, the companies that responded to the survey say they intend to hire 36% more engineers and 26% more graduates in "other technical fields" than in 1983. Demand also will rise 16% for "M.B.A. with technical B.S.," 19% for "M.B.A. with nontechnical B.S.," and 44% for accountants. Demand did not decrease for any of the master's degree categories covered by the survey.

Starting salaries at the bachelor level will rise to an average $2237 per month for engineers (up 3.5% from 1983), $2072 (up 5.8%) for computer scientists, $2016 (up 2.9%) for chemists, $1681 (up 3.7%) for accountants, $1618 (up 1.5%) for business majors, $1635 (up 4.2%) for sales/marketing majors, $1612 (up 4.2%) for liberal arts graduates, and $1707 (up 4.6%) for economics/finance majors. Although demand for math and statistics majors will drop sharply, starting salaries will rise an average 8.5%, to $1868.

For master's graduates, engineers will command the highest starting salaries (average $2580 per month), but that represents only a 2.1% increase from 1983. Masters in "other technical fields" will average $2430 (up 4.4%). Salaries will rise 5.4% to an average $2369 for "M.B.A. with technical B.S." and 4.2% to $2397 for "M.B.A. with nontechnical B.A." ☐

Boom 1984 forecast for chemical industry



Many areas of chemical performance will improve

% change 1983–84

Source: Chemical Manufacturers Association

According to predictions by the Chemical Manufacturers Association, 1984 will be a boom year for the chemical industry. CMA's annual survey of industry executives shows that they "clearly expect the nation's economy to stay up and inflation to stay down," says Myron Foveaux, CMA's assistant director of government relations for international trade and economics.

Sales are expected to increase the most, rising 13% in 1984 above expected 1983 figures. This will bring a 24% rise in income after taxes, according to Foveaux. The increased income, he adds, will come from higher sales and not from higher prices. Plant capacity utilization is also expected to increase, even after rising from 69% to 73% during the past year, reaching about 78% in 1984.

"Capital expenditures for the first time in several years will be back in their historical growth pattern," Foveaux says. CMA projects a 10% growth in capital spending over 1983. Of total spending, about 8% will go outside the U.S., 8% will be spent on environmental controls, and only 26% is expected to be spent on new facilities. The emphasis will be on renovation and modernization of existing plants.

Costs and expenditures for the industry are expected to moderate in 1984 as well. Raw material costs will rise only 5%, following the trend of the nation's inflation rate. Fuel and electric energy costs will show the biggest increase, maybe 7% next year. The hourly wage rate also will increase only moderately, around 5%, owing to the effects of long-term labor contracts, Foveaux says.

In addition, research and development spending is predicted to rise substantially, about 10% over 1983 levels. Foveaux points out that the increase is a good one since the base for R&D spending has remained high during the recession, showing the high regard chemical companies have for research.

One of the reasons behind increased research spending may be that more companies are turning away from commodity chemicals to specialties. Foveaux says CMA sees this shift as a fundamental one, heavily influenced by the international petrochemical markets. He explains that the plants now being built in natural gas-rich countries such as Saudi Arabia, Kuwait, Mexico, Canada, and Indonesia will have a great impact on worldwide capacity for petrochemicals and will affect U.S. markets to some degree. As production shifts to these countries, it seems logical that U.S. firms will react to the change by becoming world competitive in downstream products. Foveaux sees it as a good sign that chemical exports are expected to improve 6% in 1984. Chemical imports are expected to rise only 8% next year.

Foveaux comments that the growing clamor for some kind of national industrial policy inevitably will involve the chemical industry. He says that "As indistinct and ill-defined as the term is, it seems likely that the chemical industry must eventually speak to what, if any, industrial policy should be undertaken by the government." ☐

Phenol, Vinyl Acetate Head for Moderate Pickup in 1984

Although many markets are improving, these adhesives intermediates will take time to generate new major growth justifying new investment

Bruce F. Greek, C&EN Houston

In the heart of the organic chemical world, phenol and vinyl acetate are getting their share of recovery as the U.S. economy heads into what likely will be one of its better years. But behind this improvement, both chemicals have long-run problems which so far have held them back from new growth. So their producers—mostly basic chemical companies with some influence from oil and other interests—are shunning new investments at the moment.

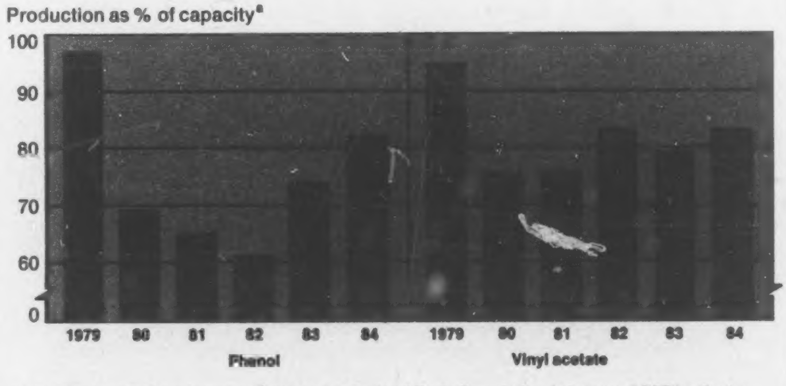
As detailed in the following pages, both phenol and vinyl acetate have potential to do well in good business years. Their important adhesives and coatings markets strengthened dramatically in 1983. If this were the only main force at work, these intermediates would be heading into tight supply in a year or two. Their use of plant capacity likely will run more than 80% in 1984; that doesn't leave much room below the practical maximum, which is a little above 90%.

Unfortunately, both chemicals have undertows in their markets. Telltale evidence is their half-decade pause in new growth from 1979 through 1984. Some countercurrents have to be at work that these intermediates cannot overcome through new uses.

Key Chemicals

For phenol, the problem is overdependence on construction markets, which aren't giving phenol growth proportionate to the big rise in housing starts this year and which could flatten out in 1984 if interest rates for mortgages inch up. Phenol's stake in construction is so great that its few major new applications, such as making aniline, cannot take up any slack.

Capacity use for both intermediates will top 80% in 1984



a First-quarter nameplate capacity. **Sources:** International Trade Commission, industry and C&EN estimates

Vinyl acetate has a much broader spectrum of uses than does phenol. Some of these uses in construction have problems similar to phenol's, others are growing in line with rejuvenated gross national product, and still others, especially in copolymers with ethylene, show strong growth. Overall, U.S. markets are moving up more than 10% per year, not bad for a commodity chemical.

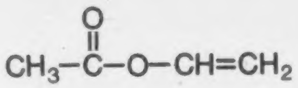
But vinyl acetate production continues on its virtual plateau of the past several years. The reason is export trouble. Weakness in exports is much more threatening to vinyl acetate than to most other organics because of vinyl acetate's unusually large foreign trade. At the peak in 1982, vinyl acetate exports took fully 37% of U.S. production. This year, that slice is dropping to about 30% as shipments abroad slump 20%. Vinyl acetate has fallen into the same export trap as have many other organics. After a boom in the late 1970s, exports are in a crunch in the 1980s because of the strong U.S. dollar, weak foreign economies, growing capacity abroad, and the loss of U.S. producers' former advantage in raw material hydrocarbon costs. Industry analysts expect continued export trouble for vinyl acetate over the next several years.

In the U.S., vinyl acetate has promising growth areas, notably in the copolymers, but volume is simply not enough to push total vinyl acetate production very much. For example, vinyl acetate content runs just 2 to 10% in copolymers for film, wire, and cable uses and 25 to 30% in adhesive grades.

The upshot for both vinyl acetate and phenol is a long haul to fresh production growth over the level of the 1970s. The outlook is similarly modest for profitability and new investments.

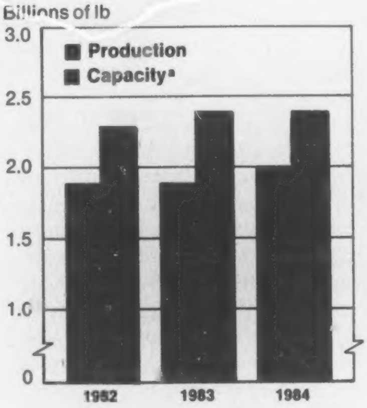
Key Chemicals

Vinyl Acetate


$CH_3-\overset{\overset{O}{\|}}{C}-O-CH=CH_2$

- ***Production inching up***
- ***Capacity holding***
- ***Prices may rise***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Vapor-phase reaction of ethylene, acetic acid, and oxygen

MAJOR DERIVATIVES (U.S.)

Polymers 55%, polyvinyl alcohol 20%, copolymers 15%

MAJOR END USES (U.S.)

Adhesives 35%, paints 25%, paper and textile coatings 20%

FOREIGN TRADE

Exports—declining to about 550 million lb in 1983, imports—about 15 million lb

PRICES

List prices 32 to 35 cents a lb

COMMERCIAL VALUE

$600 million for production, 1983

Vinyl acetate continues its strange stability among U.S. organics. In good and bad business climates for the past four years, production has been close to 1.9 billion lb. Industry analysts don't expect much movement off this plateau in 1984. The product has been in near-perfect balance between growth in new uses and economic recoveries and declines in exports and business downturns.

Such equilibrium would be frustrating in prior decades, when chemicals were expected to show net growth. But it hasn't been all that bad in the stormy business scene since 1979. For example, operating rates for vinyl acetate plants have stayed at relatively high levels while rates for most other organics have fluctuated wildly. And vinyl acetate has avoided the capacity binge since the mid-1970s that has ruined profitability in many other intermediates.

Vinyl acetate capacity, too, has been fairly steady over the past four years and, analysts think, will remain that way for the next two years. If production this year remains flat at 1.9 billion lb, the average plant operating rate will be close to 80% in the high range for organics. In 1984, vinyl acetate's relative standing may not be so high, since use rates are climbing month by month in basic chemicals. If analysts are right in predicting just a 5% output gain for vinyl acetate next year to about 2.0 billion lb, the operating rate will inch up to about 83%.

The increase in vinyl acetate production in 1984 will all go to U.S. markets, since exports are dropping. These highly important exports, about 30% of vinyl acetate's total market, have been falling for a year and are a big reason for the standstill in vinyl acetate production. Analysts forecast that exports will continue to fall as new capacity comes on in other countries and as other materials compete with vinyl acetate and derivatives in some of its major markets. The peak in exports was nearly 700 million lb in 1982 after a boom in the late 1970s. Export volume is sliding to about 550 million lb this year.

For practical purposes, all vinyl acetate is converted to polymers. Over half of U.S. demand goes to polyvinyl acetate, which becomes a component of paints, adhesives, and coatings for paper and textiles. These uses swing up and down with the general economy, especially areas such as housing and packaging. The early-1980s slump in housing combined with formulation changes to reduce demand growth for vinyl acetate in paints to low levels, with periods of decline during the sharpest drops in housing starts. In contrast to phenol's housing market, however, housing demand cannot by itself determine overall vinyl acetate production.

One reason is a second major market for polyvinyl acetate in adhesives and coatings. This is a highly diverse area. The adhesives go into uses such as box adhesives, labels, and sealing tapes. The coatings wind up in end products such as paper, where demand follows business levels because the major end use is magazines, whose page levels are sensitive to the economy's effect on advertising.

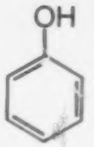
A second major vinyl acetate derivative is polyvinyl alcohol, typically about 20% of U.S. consumption. End uses for this alcohol are textile sizings, some adhesives, and many smaller categories. Growth in these uses generally is expected to be small and closely related to the growth in constant-dollar gross national product.

Further down the list of derivatives, copolymers with butyraldehyde, vinyl chloride, and ethylene take some 15% of U.S. vinyl acetate demand. Polyvinyl butyral goes almost entirely into safety glass, so its outlook depends on the state of auto production and commercial building. The other polymers go into products such as floor tile and plastic film. As a group, these vinyl acetate derivatives likely will have above average growth rates, analysts say. However, copolymer demand is too small to have much influence on total vinyl acetate volume.

Still, copolymers could be a major offset to export weakness for vinyl acetate in 1984. This, combined with any general market boost from expected good business conditions next year, could give vinyl acetate a reasonably good financial performance. Conditions are firm enough at present that major producers are attempting a price increase to help bring in the new year.

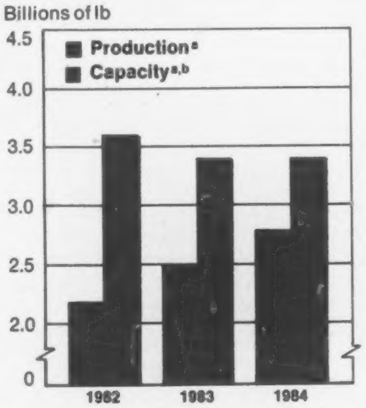
Key Chemicals

Phenol



- ***Production rising***
- ***Capacity flat***
- ***Prices off slightly***

PRODUCTION/CAPACITY



a Synthetic only. b First quarter.

HOW MADE

Peroxidation of cumene (isopropyl benzene) and cleavage to phenol and acetone

MAJOR DERIVATIVES

Resins (mostly with formaldehyde as comonomer) 40%, bisphenol A 20%

MAJOR END USES (U.S.)

Adhesives 60%, plastics 20%

FOREIGN TRADE

Exports—declining possibly to 100 million lb in 1983, imports—probably below 25 million lb

PRICES

List prices about 35 cents a lb

COMMERCIAL VALUE

$850 million for production, 1983

Phenol is finally in motion after four distressing years of poor business. The current stir includes steadily rising production, increased use of sharply pruned capacity, upward price movement, and a large-scale shift in the roster of plants. It doesn't add up yet to prosperity, but at least it's progress.

Phenol is a fairly typical big-volume organic, moving up and down with economic cycles. In 1983 production probably will top 2.5 billion lb, up more than 14% from 1982. The 1982 level was down not far from the average for organics at 15% from 1981 and 24% from the 1979 record.

For 1984, analysts predict an optimistic 10% further production gain to about 2.8 billion lb. If output gets that high—and some sources regard that figure as very iffy—it still will be below the 1979 record of 2.9 billion lb. So phenol will be finishing a half-decade pause in growth quite unexpected in the late 1970s.

The effect on plant use levels and profitability has been severe, enough to drive some producers out of this business and chop total capacity about 15% in the past two years after a 14% gain in the previous four. The worst effects of overcapacity are now over, and trimming has stopped. Capacity is now about 3.4 billion lb per year and, analysts forecast, likely will stay there for some time.

Although on paper phenol capacity is unchanged from early 1983 to early 1984, big internal shifts are taking place. Allied has completed rebuilding its large phenol plant at Frankford, Pa., which had been mostly shut down since a fire in March 1982. The capacity restoration of 500 million lb a year is in startup and probably will be capable of the full amount in 1984. Total capacity at Frankford is 600 million lb.

However, offsetting Allied's large addition will be Monsanto's exit from the business. In September, Monsanto announced that it would close its plant at Chocolate Bayou, Tex., knocking out 500 million lb of phenol capacity as well as 300 million lb of coproduct acetone.

Other small phenol units in the U.S. also did not operate for parts of 1983. With these included, analysts estimate that real nameplate capacity for the year averaged only 3 billion lb. Hence, if production reaches 2.5 billion lb this year, the operating rate at plants actually running will exceed 80%. In 1984, real capacity could be up about 13%, so actual capacity use may not rise very much.

Phenol's shock since 1979 has been due to some large mistimed capacity additions coming on stream just when phenol markets buckled. Producers have now sorted out the capacity situation but have yet to see demand recover to former levels.

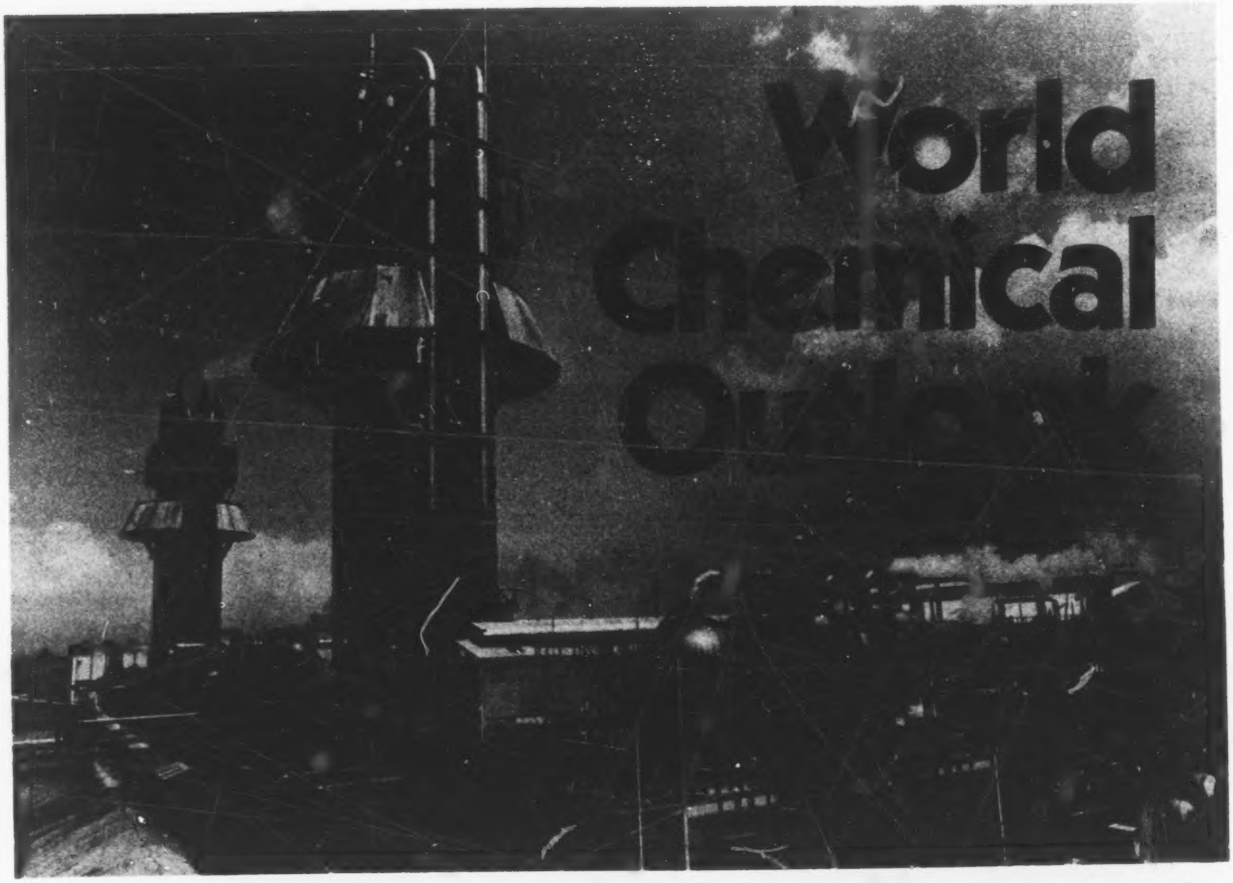
Phenol's demand problems come largely from its high dependence on housing as the end use for various derivatives. Phenol is a starting ingredient in plywood adhesives, carpet fibers, and other polymeric materials. Housing, of course, is way up from a year ago, but most current forecasts show new starts resting on a plateau through 1984. So new growth for phenol in housing may be minimal.

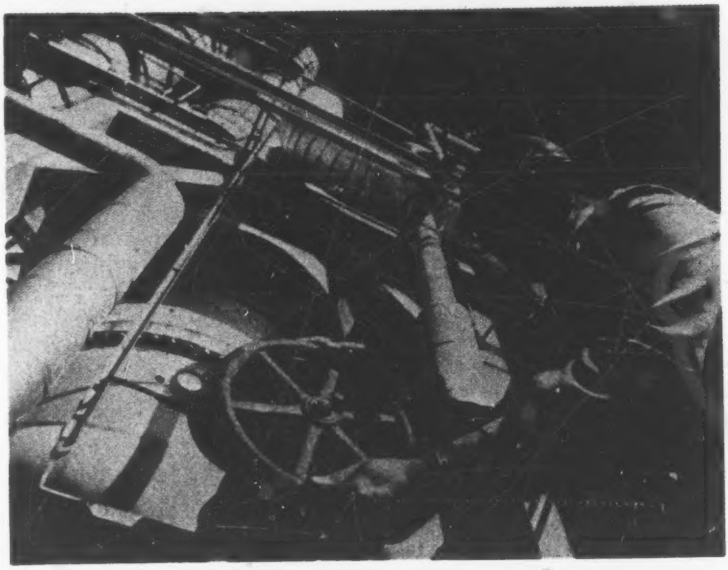
There's another trend worrying analysts about phenol's housing outlet. Many industry sources are concerned that the housing recovery has been only partially reflected in phenol demand. Reasons are downsizing of living space in newer houses, common components in nonfree-standing homes, and changes in materials combining to reduce unit demand for phenol derivatives.

Another important end use of phenol derivatives such as bisphenol A is automotive and other transportation products. These have recovered nicely from the recession, too, but again not proportionately so well for phenol. One big reason is that auto sales even by U.S. companies include an increasing number of full units and parts made abroad. Also, U.S. autos have in some cases switched to coatings not containing epoxies or other phenol-derived materials.

Since phenol doesn't have large specialty or other markets balancing its overwhelming influence from autos and housing, it cannot recover fully from the past four years until much later in the current business expansion. Possibly, phenol will not get any new growth this time around in the business cycle and may have to wait until the late 1980s.

World Chemical Outlook





The gloom that was so pervasive among the world's chemical producers during the past three years is dissipating. Just a year ago, output of chemicals was severely depressed and producers' profits seriously eroded.

Now, recovery clearly is under way for the chemical industries of Europe, Japan, Canada, and – especially – the U.S. This year's results look so good, to be sure, only when they are compared with the unsavory conditions of the two previous years. Stacked up against the robust record of the late 1970s, they still leave much to be desired.

Even so, demand for chemicals is trending upward. And the moves that were forced on the industry during the recent period of depression to trim costs, boost efficiency, and generally streamline and consolidate its operations leave it in a much stronger position to capitalize on its recent gains.

Problems still cloud the horizon, nevertheless. The industry remains burdened with more plant capacity for many major chemicals and polymers than it has any need for. Competition in world markets is cutthroat, a problem that has been exacerbated for U.S. producers, who have lost much of their former cost advantage. And the problem will only worsen as petrochemical plants in the Mideast and Latin America vie for a bigger share of world trade in chemicals.

United States 24

Foreign Trade 27

Western Europe 32

Japan 41

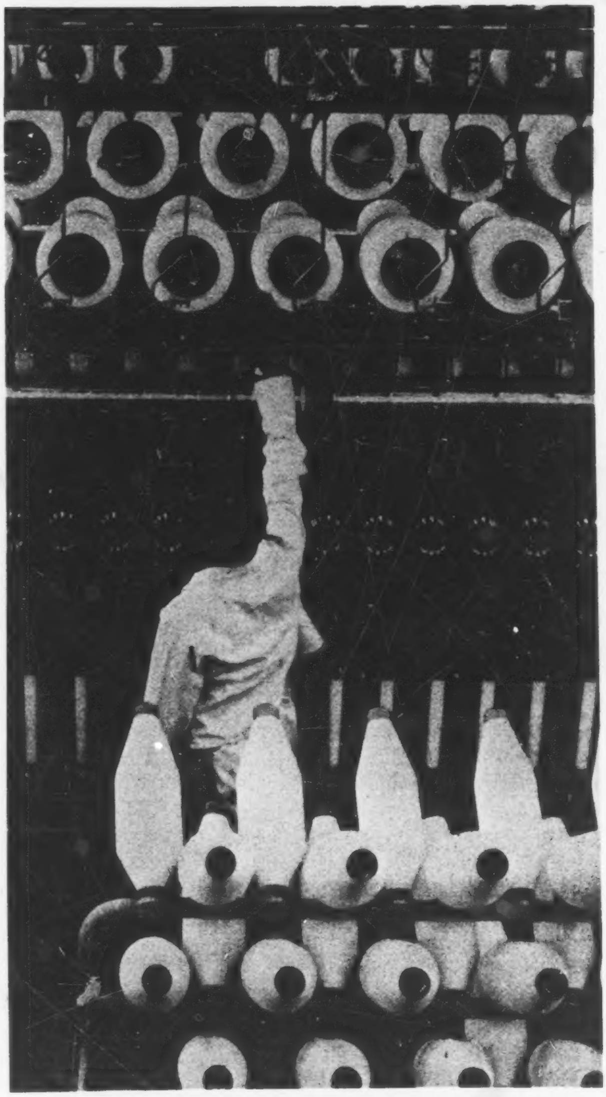
Canada 44

U.S.S.R./Eastern Europe 46

Middle East 48

Mexico 49

Brazil 50



United States

Business expected to improve further for chemical producers

Sparked by surging demand, rebound from 1982's deep recession has been stronger than expected this year

David. M. Kiefer, C&EN Washington

It has been an upbeat year for the U.S. chemical industry, in many ways the best year since the late 1970s. And as 1983 winds down, the business expansion that chemical producers have enjoyed during the past 12 to 15 months still looks robust. Industry executives, as a result, are just about unanimous in looking for further growth during 1984.

This year's recovery comes as no great surprise, to be sure. A year ago business analysts were generally optimistic about prospects for 1983, although cautiously so. The first harbingers of recovery already were in view then. Consumer spending was on the rise. Home building was rebounding from its severely depressed level at the start of 1982, and car sales were likewise recovering. Nevertheless, the overall economy remained in a deep recession, with industrial production, overall, down about 12% from the summer of 1981. And with interest rates still high and export markets being undercut by the strength of the dollar, financial crises among the underdeveloped countries, and economic slackness elsewhere, most economists were predicting that recovery in the U.S. would be sluggish and uncertain.

What has been a surprise this year, therefore, is the strength of the recovery from the long, steep descent in chemical operations that marked 1981 and most of 1982. Production of industrial chemicals and synthetic materials (such as plastics, man-made fibers, and synthetic rubber) slumped nearly 25% during 1981 and the first half of 1982. At year's end, it was still 20% lower than it had been at the start of 1981. For 1982 as a whole, output was off 14% from the year before, with organic chemicals and man-made fibers down nearly 20%. Most industry analysts were looking for gains of no more than 5% or so for 1983 in output of basic chemicals and saw little hope that operations would be fully recovered before sometime in 1984. The rebound, they feared, would be considerably less vigorous than is typical for chemicals during the recovery phase of a business cycle.

But the recovery started early and came on strong, reflecting heavy demand from such key consumers of chemical products as the housing, home furnishings, and automobile industries. Housing starts, for example, are likely to be close to 1.7 million units this year, nearly 60% more than in 1982. And increased home building has stimulated demand for appliances, where production is up about 16% this year, and furniture, output of which is about 20% ahead of last year. With auto sales this year expected to top 1982's sales about 18%, U.S. car production will be more than 30% greater than last year, and production in the fourth quarter alone nearly 60% ahead of the like period of 1982.

Other chemical consuming industries also have been healthier. Shipments of aluminum ingot and mill products are running about 15% ahead of last year. Production of paper and paperboard probably will be up 7% for the year. Tire output is likely to be 12 to 15% higher than last year.

In addition to supplying the rising demand from such chemical customers, chemical producers also have had to build up inventories that had been depleted during the slack period of last year to keep operating costs at a minimum.

As a result, production of chemicals and synthetic materials now is about 20 to 22% higher than it was at the end of 1982 and is almost back to the same level as two years ago, just before the recession got under way. For the year as a whole, production probably will be about 14% higher than in 1982, a gain that is nearly triple what many industry officials had forecast.

The increases are widespread, as well. Output of many key petrochemicals, such as ethylene, cumene, cyclohexane, and benzene, probably will be 18 to 20% or more above last year's level. Plastics production overall probably will be 15 to 20% higher than in 1982, with polypropylene's 25 to 30% increase setting the pace among the major thermoplastics. Synthetic fibers production this year is expected to top that of 1983 15 to 18%, with nylon turning in a particularly good year among the big-volume fibers. Even some of the workhorse inorganic chemicals have made a strong comeback.

The one major outlet for chemicals that has been laggard is the farm market. The government's payment-in-kind (PIK) program and last summer's severe drought in the Midwest caused a sharp decline in this year's harvests. The PIK program alone reduced corn acreage about 28% and the total corn crop this year is expected to decline about 45%.

Cotton and soybean harvests also are well below those of 1982. Meanwhile, export markets for U.S. farm products have been weak for the second year in a row.

The result has been a decline in the amount of fertilizer and other agricultural chemicals needed by U.S. farmers. Output of farm chemicals, therefore, was lower than the year before throughout most of 1983. Although output now is beginning to move upward again as farmers increase acreage substantially during the coming year, for 1983 as a whole production of all types of agricultural chemicals may be 5 to 7% less than the previous year, with ammonia output alone off 4 to 5%.

For makers of agricultural chemicals, therefore, 1983 has been a year of lower sales volume and poor earnings. The fertilizer operations of Williams Cos., for example, had an operating loss of $13 million for the nine months ending last Sept. 30 on a 16% decline in sales revenues. For Monsanto, sales of agricultural products were down 9% for the nine-month period, and operating income for agricultural and nutritional products combined was 24% lower than in 1982.

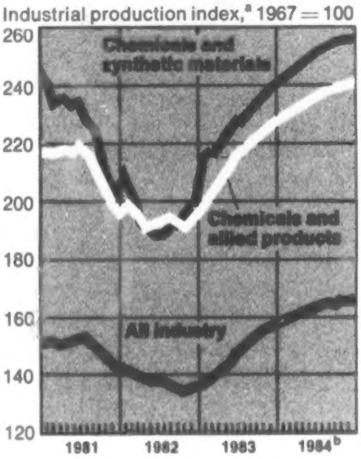
Another weak spot this year has been overseas markets. Continuing weak economic activity throughout much of the world, austerity measures on the part of many debt-plagued underdeveloped nations, and the strength of the U.S. dollar relative to major foreign currencies combined to squeeze U.S.-made chemicals out of many foreign outlets. Losses stemming from currency translation problems also remain troublesome for U.S. chemical companies with sizable business operations abroad.

But most of the other factors influencing profits were much more favorable this year than last. Firmer demand has done much to improve selling prices for chemical products, for one thing—prices that had been noticeably weak during 1982 and early 1983. For industrial chemicals, selling prices by midyear were 8% below their peak of mid-1981. Not all producers have been able to make intended price increases stick, but on the average prices now are about 4% higher than last summer and higher than at any time in more than a year and a half. Price trends are more favorable, too, for plastics and synthetic fibers.

At the same time, increased production has resulted in greatly improved rates of capacity utilization for chemical producers. Operating rates have moved above 70% for plants making major basic chemicals to the highest level in the past two years. For plastics, operating rates now are above 80%, compared to well under 70% in 1982; for synthetic fibers, the rate is pushing close to 90%, also up from less than 70% last year. Overcapacity is not a problem that has been fully solved by the chemical industry, but it's much less of a problem than it had been a few years ago.

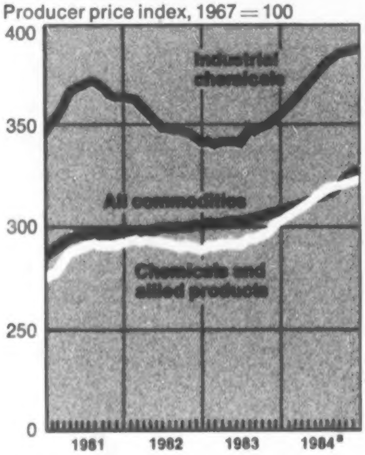
Meanwhile, the stringent measures that the industry took in the past couple of years to control costs are still largely in place. The industry, as one executive puts it, "is still operating lean and mean." Capital expenditures have been curtailed or

Output will continue to move up next year . . .



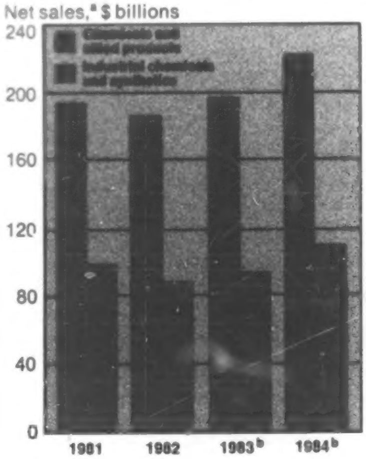
a Seasonally adjusted. b C&EN estimates.
Source: Federal Reserve Board

. . . and selling prices will be marked up . . .



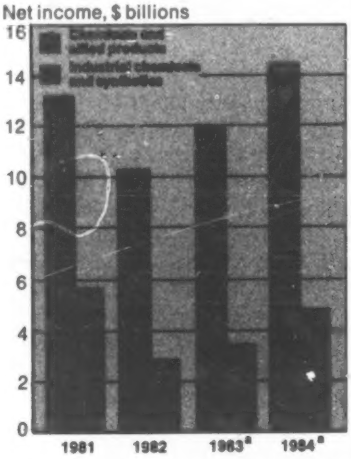
a C&EN estimates.
Source: Bureau of Labor Statistics

. . . giving a strong boost to chemical makers' sales . . .



a Excludes sales of foreign subsidiaries. b C&EN estimates. **Source:** Bureau of the Census

. . . and an even bigger lift to profits



a C&EN estimates.
Source: Bureau of the Census

This year's recovery in production of most chemicals will be extended in 1984

	1984	1983	1982	1981
INORGANIC CHEMICALS				
Thousands of tons unless otherwise indicated				
Ammonia	17,000	14,900	15,500	19,076
Chlorine gas	11,200	10,300	9,120	10,767
Hydrochloric acid	3,000	2,800	2,483	2,502
Nitric acid	8,600	7,300	7,587	9,077
Oxygen, billions of cu ft	420	370	349	431
Phosphoric acid	10,900	9,950	8,523	9,922
Sodium hydroxide	11,500	10,600	9,141	10,414
Sulfuric acid	39,200	35,500	32,682	40,795
ORGANIC CHEMICALS				
Millions of lb unless otherwise indicated				
Acetic acid	2,750	2,500	2,748	2,705
Acetone	2,200	2,000	1,694	2,144
Acrylonitrile	2,250	2,150	2,035	1,996
Benzene, millions of gal	1,500	1,300	1,069	1,339
Butadiene	2,500	2,300	1,915	2,986
Cumene	3,550	3,300	2,743	3,309
Cyclohexane	1,700	1,550	1,275	1,820
Ethylene	32,000	29,000	24,501	29,418
Ethylene glycol	4,900	4,500	4,309	4,143
Formaldehyde	5,900	5,450	4,817	5,721
Methanol	8,100	7,400	7,555	8,577
Phenol	2,800	2,550	2,175	2,578
Phthalic anhydride	900	800	684	870
Propylene	15,600	14,400	21,535	13,482
Styrene	7,200	6,600	5,942	6,679
***o*-Xylene**	900	800	802	918
***p*-Xylene**	4,500	4,200	3,391	4,532
PLASTICS				
Millions of lb				
Polyethylene, high density	6,400	5,800	4,928	4,695
Polyethylene, low density	8,600	8,100	7,503	7,693
Polypropylene	5,000	4,500	3,477	3,955
Polystyrene	3,850	3,550	3,191	3,621
Polyvinyl chloride	6,850	6,300	5,326	5,707
SYNTHETIC FIBERS				
Millions of lb				
Acrylic and modacrylic	750	690	624	691
Nylon	2,600	2,400	1,927	2,332
Olefin and vinyon	1,000	900	723	785
Polyester	3,850	3,550	3,169	4,176

Sources: Bureau of the Census, International Trade Commission, Society of the Plastics Industry, Textile Economics Bureau, C&EN estimates (for 1983 and 1984)

shifted to projects designed to cut costs or improve efficiency. Spending on new plants this year will be 23% less than in 1982, which in turn had been 11% under that of 1981.

Employment rolls also have been trimmed drastically. In the overall chemicals and allied products industry, total employment is down about 50,000 workers from two years ago.

Increased demand and firmer prices have been a boon to chemical companies' financial health. Sales volume for producers of industrial chemicals and synthetics was up about 5% from last year through the first nine months of 1983 and the year-to-year comparison for the current quarter undoubtedly will be considerably more favorable. For the entire year, therefore, C&EN estimates that sales will be 7% higher than in 1982—although even so they will be about 4% lower than two years ago. For the broader chemicals and allied products industry, sales for the year are likely to rise 6% to a new all-time high.

Profits will make an even stronger comeback from the dismal slump of last year. Earnings during the final three months of the year will look particularly impressive when stacked up against the rock-bottom level of 1982's last quarter and may even be double earnings of that period. For the year as a whole, then, earnings may well be 20 to 25% ahead of last year for producers of industrial chemicals and synthetics and about 15% for chemicals and allied products.

Next year's financial results are expected to look even more glowing. Although a few maverick economists see dark clouds gathering over the national economy and talk gloomily of the threats inherent in huge federal deficits, high interest rates, and shaky international finances, the majority are essentially optimistic. As Du Pont economist Charles B. Reeder sums up the outlook, "All of the elements are present to make 1984 an unusually good year."

The consensus is that gross national product will climb 4 to 6%, after adjustment for inflation, that industrial production will be 8 to 10% higher than this year, and that unemployment will drop below 8% of the labor force by the end of the year, if not sooner.

For chemical producers, this makes a favorable climate. The housing boom is expected to level off, with new starts about the same as this year. Exports of chemicals will continue to be thwarted by the strength of the dollar. On the other hand, automobile production is pegged by Detroit for another strong gain. And the acreage planted by farmers will expand substantially, providing sharply increased demand for fertilizer and pesticides.

C&EN estimates, consequently, that production of chemicals and synthetic materials next year will be up 11%, with the sharpest gains coming during the first half of the year. For all chemicals and allied products, the increase will be only a slightly more modest 10%. Prices will continue to rise, with the year as a whole averaging about 8 to 10% higher for industrial chemicals. That means a further increase, too, for sales volume, perhaps as much as 14 to 16%, for producers of industrial chemicals and synthetics. And profits, in turn, can be expected to surge 30 to 35%, if not more. Even so, the industry's profits will not match those of 1981. ☐

U.S. surplus in chemical trade narrows again as exports drop

Although world trade in chemicals is higher, the U.S. share of the world market will shrink this year

Earl V. Anderson, C&EN New York

All is not right with world chemical trade. But at least it is better than it was a year ago.

Better, that is, for most of the major chemical trading nations, but certainly not for the U.S. Although total world trade in chemical products will increase this year, U.S. chemical exports will drop for the second year in a row. This means that the U.S. share of world chemical markets also will decline for the first time in the past five years. And coupled with a sizable increase in U.S. chemical imports, the decline in imports also means that the U.S. chemical trade surplus will take another beating.

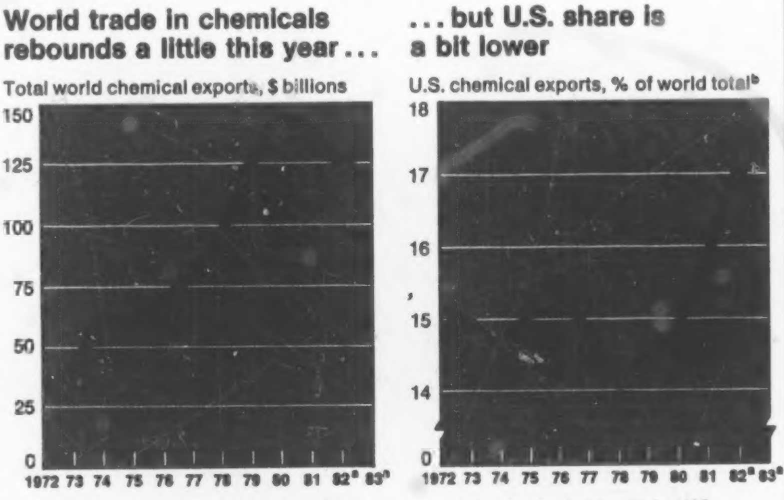
There is very little that chemical industry executives can do about the decline, except to try harder. Many of the factors that are lined up against U.S. chemical exports and in favor of chemical imports are the same factors that are hurting U.S. exports and encouraging the growth of U.S. imports in general. They are beyond the control of the chemical companies.

The strong dollar, a solid economic recovery in the U.S., a much slower-paced recovery abroad, and overwhelming debt problems in many of the developing countries that are strong markets for U.S. exports are just a few of the factors that are raising havoc with the U.S. trade balance.

Of them all, the strong U.S. dollar has received the most attention, if not corrective action. A strong dollar hurts exports by making them more expensive overseas and thus less competitive against foreign-made products. The dollar, says Robert Lawrence, a senior fellow at Brookings Institution in Washington, D.C., is pricing U.S. companies out of the international market. It also sucks more imports into the U.S. because they become less expensive.

The dollar is widely considered to be overvalued against many foreign currencies. On a trade-weighted basis, it has appreciated 50% since early 1980. Since late 1978, it has risen more than a third against the Japanese yen, while inflation in the U.S. was running at least 20% greater than in Japan. This has produced a "stunning" deterioration of more than 50% in U.S. price competitiveness against its major rival in international trade, says C. Fred Bergsten, director of the Institute for International Economics.

And, adds Bergsten, the current overpricing of the dollar has the same effect as placing a 20 to 25% tax on all U.S. exports and paying a similar subsidy on all U.S. imports. Eliminating this price disadvantage, he says, will do more to revitalize the international competitiveness of U.S.



World trade in chemicals rebounds a little this year . . .

. . . but U.S. share is a bit lower

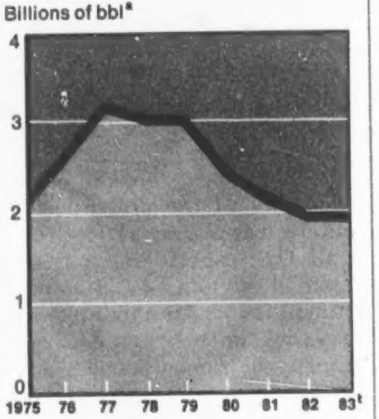
a C&EN estimates. b Defined as: U.S. chemical exports as per cent of world chemical exports less U.S. chemical imports. Sources: United Nations, Bureau of the Census

Drop in chemical exports is widespread; organic chemicals, plastics pace import growth

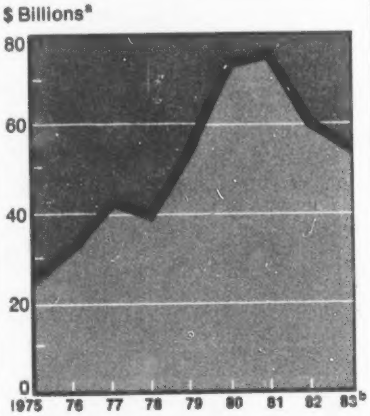
$ Millions	U.S. chemical exports 1983[a]	1982	1981	1980	U.S. chemical imports 1983[a]	1982	1981	1980
Organic chemicals	$ 5,134	$ 5,440	$ 5,929	$ 5,697	$ 3,459	$2960	$2974	$2541
Plastics and resins	3,680	3,650	3,809	3,884	1,030	766	780	647
Medicinals and pharmaceuticals	2,438	2,275	2,165	1,932	705	563	583	509
Inorganic chemicals	1,782	1,969	2,286	2,106	1,562	1502	1573	1324
Radioactive materials	1,312	1,132	988	833	921	1143	786	990
Fertilizers, manufactured	1,276	1,386	1,735	2,265	984	963	1181	1105
Pesticides and disinfectants	613	607	544	553	262	265	283	264
Flavors, perfumes, cosmetics, and toiletries	478	514	535	479	375	295	289	302
Pigments, paints, and varnishes	322	332	349	304	140	103	102	89
Cleaning and polishing materials	296	324	396	327	91	76	74	72
Dyeing, coloring, and tanning materials	163	162	175	186	296	213	226	195
Explosives and pyrotechnics	86	90	90	87	68	67	61	59
Miscellaneous	1,920	2,010	2,187	2,087	757	579	534	497
TOTAL	$19,500	$19,891	$21,187	$20,740	$10,650	$9494	$9446	$8594

a C&EN estimates. **Source:** Bureau of the Census

Volume of U.S. oil imports remains at low level...



...but their cost declines further



a All petroleum products. b C&EN estimate. **Source:** Bureau of the Census

companies than concocting an industrial policy, which is the new buzz word in Washington.

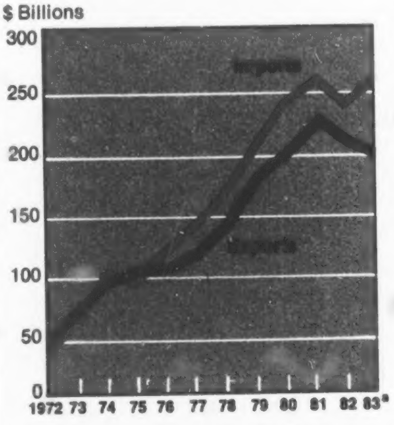
The present value of the dollar is as high as it is because of the large U.S. budget deficits, most economists agree. Huge deficits, by pushing up interest rates, lure foreign currency into U.S. financial markets. This increases demand for dollars which, in turn, pushes up foreign exchange rates.

Whatever the reason, the strong dollar is helping to send the U.S. trade deficit into orbit. This year, the deficit will leap to $55 billion, a whopping 72% higher than it was last year and a new record for U.S. trade deficits, although a record that no doubt will be broken again next year. You have to go back to 1975 to find the last time the U.S. had a trade surplus.

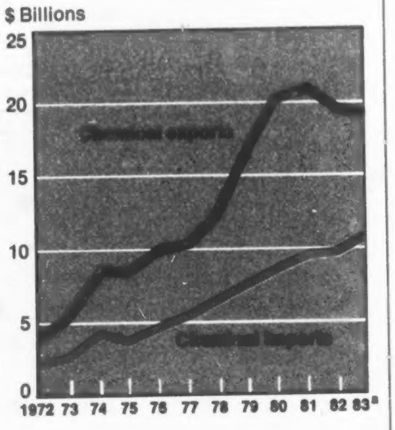
Given the strength of the economic recovery in the U.S., this year's increase in imports seems modest—about 4.5% to $255 billion. But the bill for imported oil is down sharply this year, from $60.5 billion in 1982 to $53 billion. That means that imports of other products increased more than the total import figure indicates. Indeed, most categories of imports are higher this year than last, especially machine and transport equipment.

Exports, meanwhile, have not

Overall U.S. trade deficit continues to widen...



...while the chemical trade surplus shrinks slightly



a C&EN estimates. **Source:** Bureau of the Census benefited from the lukewarm recovery abroad. U.S. exports this year will be down about 6% to $200 billion, with all product areas, even agricultural products, sharing the decline.

Chemical exports are no exception. This year's decrease isn't so bad as that of last year, when chemical exports fell 6%. Nevertheless, chemical exports probably will total about $19.5 billion for 1983, 2% lower than last year.

Chemical imports, however, will reach a milestone of sorts by topping $10 billion for the first time in 1983. Best estimates are that they will reach $10.7 billion, a hefty 12% improvement over last year.

With very few exceptions, the U.S. chemical industry traditionally has chalked up surpluses in its foreign trade. In 1980, the trade surplus climbed to a record $12.1 billion. But it has shrunk more than 25% in the past three years and this year will be down to only $8.9 billion.

This erosion of the chemical industry's cherished trade surplus is creating more than a little concern among industry trade experts. And it helps explain why more industry spokesmen and position papers are getting an airing at government hearings, especially in Congress, on matters related to U.S. trade with the rest of the world.

One example of proposed legislation stemming from this concern is the Trade Remedies Reform Act of 1983 (the Gibbons Bill). This bill would reform antidumping and countervailing duty laws and probably provide sanctions against both preferential pricing of natural resources by other countries and industrial targeting.

This and other proposed legislation, such as the domestic content bill, are aimed at disruptive imports. They do nothing to help exports.

The biggest obstacles impeding U.S. chemical export growth, in addition to the strong dollar, are the slow-to-recover economies in many other industrialized countries and the massive external debt problems in many developing nations. Among developed countries, only chemical exports from the U.S. to Canada will show any sizable gain this year.

That's not surprising because Canada's economy is tied so closely to that of its southern neighbor that when the U.S. economy perks up, Canada's also perks up. As a result, U.S. chemical exports to Canada will increase almost 15% this year to $2.5 billion.

That kind of growth certainly won't be visible for chemical shipments to Western Europe or Japan this year. And sales to most developing areas are either stagnant or down.

This is especially true of Latin America, the largest market for U.S. chemicals in the developing world and the second largest target anywhere after Western Europe. When chemical exports to Latin America drop a painful 11%, as they will this year, the impact on the operations of U.S. chemical companies will be severe.

Next year could see some improvement in U.S. chemical exports. Economic recovery probably will be more entrenched in Europe and in Japan. With help from the international banking community, debt-ridden developing countries may be in a better position to ease up on import restrictions. And some economists believe that the value of the dollar will decline relative to other currencies.

However, others fear the adverse effects of a strong dollar will continue, and may even get worse in the year ahead. □

Lower demand in Latin America hurts U.S. chemical exports

$ Millions	1983[a]	1982
U.S. CHEMICAL EXPORTS		
Canada	$ 2,509	$ 2,183
Latin America	3,284	3,670
Western Europe	6,027	5,940
Eastern Europe	265	366
Japan	2,476	2,530
Communist Asia	344	497
Middle East	447	533
Rest of Asia	2,688	2,600
Australasia	691	655
Africa	465	524
Other	304	393
TOTAL	$19,500	$19,891
U.S. CHEMICAL IMPORTS		
Canada	$ 2,353	$ 2,596
Latin America	963	613
Western Europe	4,940	4,174
Eastern Europe	190	151
Japan	1,085	879
Communist Asia	127	136
Middle East	124	99
Rest of Asia	266	220
Australasia	228	286
Africa	214	225
Other	160	115
TOTAL	$10,650	$ 9,494

a C&EN estimates. Source: Bureau of the Census

Exports slump across the board but imports are higher for nearly everything except fuels

	U.S. exports				U.S. imports			
$ Billions	1983[a]	1982	1981	1980	1983[a]	1982	1981	1980
Chemicals	$ 19.5	$ 19.9	$ 21.2	$ 20.7	$ 10.7	$ 9.5	$ 9.4	$ 8.6
Machinery and transportation equipment	82.5	87.1	95.7	84.6	84.1	73.3	69.7	60.5
Other manufactured goods	30.2	33.0	37.3	38.6	66.2	61.1	63.4	55.9
Food and live animals	23.5	24.0	30.3	27.7	15.7	14.5	15.2	15.8
Beverages and tobacco	2.7	3.0	2.9	2.7	3.4	3.4	3.1	2.8
Mineral fuels, lubricants, and related materials	10.1	12.7	10.3	8.0	57.2	65.4	81.4	79.0
Crude materials (inedible) other than fuels	18.5	19.2	21.0	23.8	9.3	8.6	11.0	10.5
Animal and vegetable oils and fats	1.3	1.5	1.7	1.9	0.4	0.4	0.5	0.5
Miscellaneous products	7.1	6.9	8.4	8.4	8.0	7.7	7.3	7.2
TOTAL[b]	$200.0[b]	$212.2[b]	$233.7[b]	$200.6[b]	$255.0	$244.0	$261.0	$240.8

a C&EN estimates. b Includes re-exported imports (not included in individual product categories). Source: Bureau of the Census

Western Europe

Recovery is under way but overcapacity remains a problem

Though many plants already have been shut down, chemical officials see need for still further cutbacks in capacity

Dermot A. O'Sullivan, C&EN London

Chemical companies in Western Europe have come through 1983 in reasonably good shape. Demand gained momentum as the year progressed. Corporate results appear positively bullish when set against 1982.

One helping factor is that the usual midsummer lull didn't materialize. BASF chairman Hans Albers sums up the position by saying, "This spring, the economic climate was often described in these words: 'The mood is better than the situation.' Today, I can say, 'The situation is at least as good as the mood.' "

The improvement shows through in the financial results of major chemical companies. For the nine months ending with September, in contrast to a year earlier, Akzo's sales were up 4%, BASF's 6%, Bayer's 5%, Hoechst's 4%, and Imperial Chemical Industries' 12%.

More significant was the across-the-board surge in pretax profits—Akzo 153%, BASF 57%, Bayer 77%, Hoechst 87%, and Imperial Chemical Industries (ICI) 119%. Contributing in large measure to the upswing were the emergency actions that all these companies initiated in the past two years. Plant closures, restructuring, layoffs, and the like helped boost plant utilization and partly offset the rise in operating expenses stemming from higher energy and feedstock costs. Moreover, companies have upped selling prices successfully throughout the year.

Although no one knocks these healthier figures, managers continue to complain that profit margins for many products remain squeezed. Ironically, too, the improvement in corporate balance sheets has prompted an element of concern. Comments David Oxley of Chem Systems' London office, "Renewal of business confidence there may be. But there is a worry that this confidence may be a bit too euphoric. People may decide to build another plant, or not to close down one they were thinking of shutting."

Adds Thomas O. Hutchison, ICI's petrochemicals and plastics division chairman, "Though we are in the black, we are not anything at a reasonable level of profitability. I hope the industry does not become complacent as trade improves." His division, in the red since 1979, finally managed to break even in this year's third quarter. This, as Hutchison bluntly puts it, "was one hell of an achievement."

In much the same vein, Gaston Beauregard, head of planning at Shell International Chemical's petrochemicals division, stresses "the continuing need for rationalization. Everybody should be looking at it because everybody can do something. We are enjoying a bit of a breather, but we are not through the woods yet." During this year's first nine months, Shell's worldwide chemical operations (excluding Canada and the U.S.) earned about $47 million, its first profit since 1979. "But it's still peanuts considering the amount we have invested in chemicals," Beauregard remarks.

The recent improvement in the financial returns of European chemical companies has been influenced largely by the upturn in the U.S. economy and the continued strengthening of the U.S. dollar against European currencies. Rising U.S. demand has tended to suck materials in from Europe. Moreover, goods priced in dollars have become much more expensive in European currency terms. Conversely, European-made chemicals and derivatives are more competitive in world markets against products priced in dollars.

Within Europe itself, demand is being influenced by stockbuilding in advance of rising prices. Although there has been some increase in consumer spending on such items as automobiles, household goods, and the like, all of which need chemicals in their production, this has been outpaced by the filling of inventory pipelines.

These influences can be seen in this year's sales pattern of commodity plastics. In the case of low-density polyethylene, for example, West European production is 15% ahead of 1982. European sales are up about 10%, but exports have advanced 30%. Likewise for polypropylene, the 10% or so increase in European sales is dwarfed by a 40% rise in exports. Polyvinyl chloride has followed much the same pattern. Production is up 8%, local sales are up about 4%, but exports are up 40%.

According to Chem Systems, European low-density polyethylene and polypropylene plants currently are running at about 90% of their effective capacities and polyvinyl chloride plants at between 70 and 80%, rates which are well ahead of last year.

Higher utilization rates undoubtedly also reflect rationalization steps that producers embarked on when the slump in sales and profits began to bite. Senior management of all the major European chemical producers profess themselves to be committed to continuing the process. Nevertheless, some of the edge appears to have come off the drive. As Robert B. Horton, managing director of BP Chemicals International, noted at the European Petrochemical Association conference in Monte Carlo this fall, "After a good start in 1982, this year has seen more and more talk about the subject and less and less action."

Citing ethylene crackers as an example, Horton notes that West European nameplate capacity currently stands at 32 billion lb, 9.5% below the level at the close of 1980. U.K. capacity has been cut 30% (1.3 billion lb), although most of that will be restored when the Esso/Shell cracker going in at Mossmorran, Scotland, comes on stream in 1985 with its 1.1 billion lb-a-year capacity. Next in terms of cuts in ethylene capacity are West Germany (21%, 2.2 billion lb), Belgium/Netherlands (14%, 1.0 billion lb), and France (3%, 200 million lb). In Italy, capacity actually increased 25% to 3.9 billion lb, and throughout the rest of Western Europe capacity rose 12% to 5.4 billion lb.

Despite the overall decline, ethylene capacity still is well ahead of the 25.3 billion lb-a-year demand level. Horton reasons that when the Mossmorran unit comes on stream, 3.5 billion lb of ethylene-making capacity will have to be closed permanently in Western Europe to allow remaining units to operate at 85% or so of their design levels.

Shell International Chemical's Beauregard likens rationalization to drying a wet towel. "The first twist produces a lot of water. But as you keep turning it, it's very hard to get it completely dry. Closures were at sites with more than one cracker. There wasn't the pain of closing the last one. Now we are coming to candidates for closure where it is much tougher to make a decision."

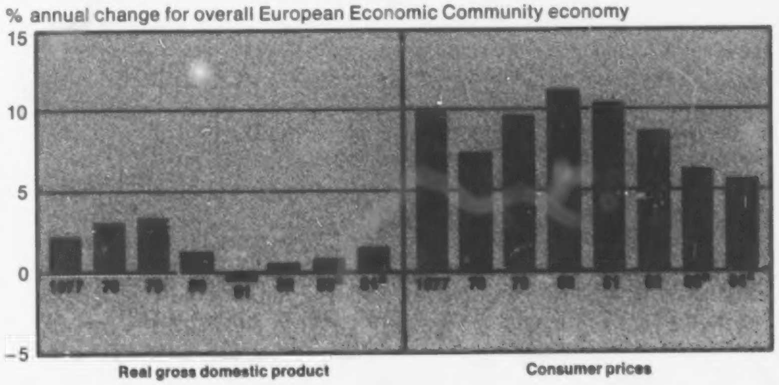
West European growth prospects for commodity plastics, the main outlet for cracker-derived olefins, appear limited. Between 1983 and 1987, according to Falk von Tettenborn, Hoechst's director of plastics marketing, consumption of high- and low-density polyethylene, polypropylene, polystyrene, and polyvinyl chloride in Europe is likely to grow a marginal 1.4% a year to 27.9 billion lb.

For polystyrene, he foresees an average annual growth in consumption of 1.4% to 2.8 billion lb. He expects high-density polyethylene and polyvinyl chloride to grow about 1.7% a year to 3.6 billion lb and 8.8 billion lb, respectively, whereas use of low-density polyethylene will decline 0.3% a year to 8.6 billion lb. Polypropylene holds the only promise of reasonable growth, which von Tettenborn pegs at better than 4% annually to 4.1 billion lb.

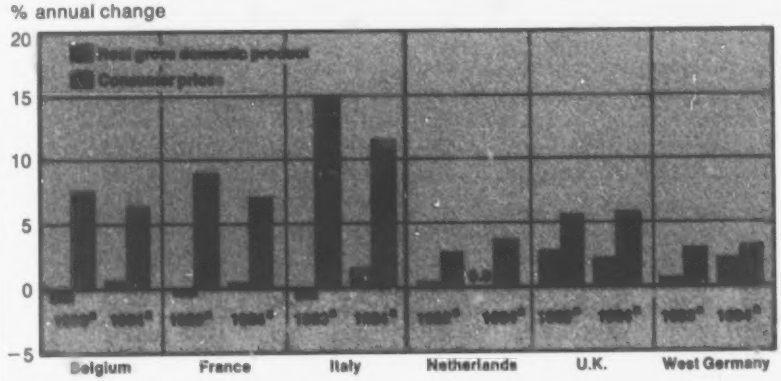
Such tempered projections contrast with these polymers' lively performance this year. Von Tettenborn notes that the 26.4 billion lb of commodity plastics consumed throughout Western Europe is ahead 6% from 1981. The biggest gains were made by polypropylene (9% to 3.5 billion lb), LDPE (9% to 8.7 billion lb), and HDPE (8% to 3.4 billion lb). PVC consumption moved forward 4% to 8.2 billion lb. Polystyrene's growth was a weak 1% to 2.6 billion lb.

Reflecting the criticism of the industry voiced by BP Chemicals' Bob Horton, Simon D. de Bree, vice president of DSM's plastics division, deplores the fact that the economic upturn has induced several producers in Western Europe to postpone closure of production facilities. "So long as the existing overcapacities are

Economic growth is slow but inflation is easing . . .



. . . at least in countries where it has been highest



a Estimated. **Source:** Commission of the European Communities not further reduced," he warns, "there will be no question of structural recovery in this branch of industry. Additional closures are definitely required."

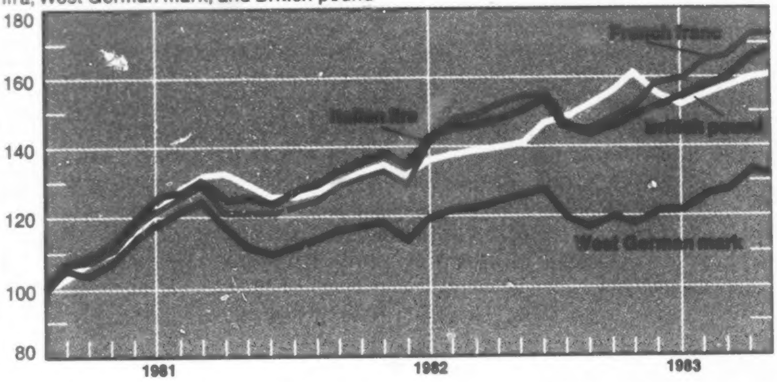
European producers of synthetic fibers have taken rationalization to heart, and their moves appear to be paying off. "The situation now has improved substantially," remarks Jean-Louis Juvet, director general of the Paris-based International Rayon & Synthetic Fibers Committee (CIRFS). "Today's structure of the industry is more in line with potential sales. Surplus capacities have been largely reduced. Through better utilization of capacities, most companies' fibers operations should be in the black this year."

Overall, some 1.1 billion lb (about 17%) of fiber-making capacity has been taken out of service during the past two years under a scheme drawn up under CIRFS' guidance. The decrease follows earlier cuts of about 880 million lb. The view at Hoechst, nevertheless, is that even though "the industry in Western Europe seems to have recovered after a three-year period of stagnation, and demand for textile fibers is lively, the basic problem of overcapacity is not yet satisfactorily solved."

In absolute terms, sales of about 1.3 billion lb of polyamide and 1.7 billion lb of polyester fibers in Western Europe this year will be about level with last year, with sales of acrylics up about 10% to 1.6 billion lb. Despite no growth in polyamides and polyesters, companies in the business are showing better financial returns.

Dollar continues to strengthen versus European currencies

Relative value of U.S. dollar vs. French franc, Italian lira, West German mark, and British pound[a]



[a] January 1981 = 100.

Akzo of the Netherlands, long plagued by its fibers business worldwide, registered operating income from fibers at the end of this year's first nine months of $30.5 million, in contrast to the $334,000 loss the previous year calculated on the same currency exchange basis. "The rate of utilization of Enka Europe plants was satisfactory," company management observes, although "selling price levels, notably for textile and carpet fibers, were still too low, thus limiting the improvement."

Better returns on fibers, yarns, and fabrics led to London-based Courtaulds' 169% surge in pretax profit on these items to $54.8 million in the first six months of its business year, through September. For ICI, which has lost money on fibers each year since 1974, "fibers still have not emerged into profit, but losses are at a reduced level compared to 1982." With marketing conditions still difficult and the European market remaining flat, higher levels of exports to the U.S. compensated to some extent, a company spokesman notes. ICI decided two years ago to move away from commodity synthetic fibers, concentrating instead on high-quality specialties aimed at the upper end of the market.

Monsanto dropped entirely out of fibers production in Europe with the sale this year of its acrylic fiber operations in Coleraine, Northern Ireland, and at Lingen, West Germany. Montefibre, the fibers arm of Italy's Montedison, now runs the 66 million lb-a-year Coleraine plant and Bayer owns the 79 million lb-a-year Lingen facility.

CIRFS' Juvet observes that imports from the U.S., once a thorn in the side of Western Europe's fiber producers, "have all but disappeared [owing] to the dollar's present exchange rate." He is concerned, however, that "when people here start making money again, outsiders might come in." He also believes that "we might have problems with Turkey, where acrylic fiber capacity is going up."

Observers may score European chemical companies for not rationalizing operations to the extent that should be done. But they can hardly criticize the companies for not taking steps to restructure, regroup, and consolidate. Moves along these lines have been widespread this past year. Some examples:

- Exxon reached agreement with the Greek government to sell its 3.5 million ton-a-year oil refinery and associated petrochemical complex at Thessalonica. Chemical operations include a naphtha cracker with an annual ethylene output capability of 110 million lb. Other products are ammonia, chlorine, polyvinyl chloride, fertilizers, and solvents.
- ICI, already big in fertilizers and plant chemicals, acquired the fertilizer and agrichemicals business of Albright & Wilson, the wholly owned U.K. subsidiary of Tenneco. Included are plants for making ammonium nitrate, compound fertilizers, and a range of pesticides. The move follows this year's acquisition of Hargreaves Fertiliser Industries, also in the U.K.
- Monsanto became sole owner of Polyamide Intermediates through its

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purchase of Montedison's half-interest. Set up in 1974, the company has units at Seal Sands, on England's east coast, for making 198 million lb a year each of adiponitrile and hexamethylene diamine, intermediates for nylon production. Monsanto ships most of the output to its U.S. operations.

- Norsk Hydro of Norway strengthened its position in polyvinyl chloride by buying two plants in the U.K. with combined annual capacity of 330 million lb. This month, it agreed to acquire Kemanobel's 242 million lb-a-year polyvinyl chloride operations in Sweden. Included are plants for making caustic, chlorine, and vinyl chloride.

But it is France and Italy where the most sweeping changes in chemical company structures are taking place. Corporate realignments, which got under way in earnest last year, continued throughout this current year.

The moves in France are a continuation of plans drawn up by the Socialist government under president François Mitterand soon after the national election two years ago. The objective is to reshape and revitalize all sectors of the chemical industry—fertilizers, fibers, commodity products, petrochemicals, and pharmaceuticals—to streamline what had been an extremely complex infrastructure of interlinked company affiliates and subsidiaries.

Not surprisingly, the task has encountered difficulties. Top executives—including the heads of Société Nationale Elf Aquitaine and of Rhone-Poulenc—have quit or been fired because of disagreement with government policies. Much yet remains to be accomplished. But there are clear signs of progress. The principal companies involved are CdF Chimie, Compagnie Française des Pétroles (Total), Elf Aquitaine, Rhône-Poulenc, and Produits Chimiques Ugine-Kuhlmann (PCUK), defunct subsidiary of the international metals and mining giant, Pêchiney-Ugine-Kuhlmann.

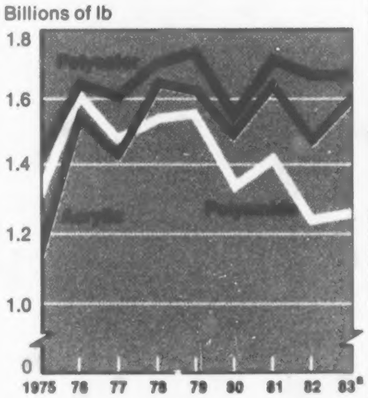
Rhône-Poulenc now drops to second place among French chemical concerns after Elf Aquitaine. Elf, which already had extensive chemical interests in addition to its oil activities, will take on the bulk of PCUK's operations. It also assumes full ownership of Ato Chimie (organic chemicals, petrochemicals, and plastics) and Chloé Chimie (inorganic and organic chemicals and polyvinyl chloride), which it had owned jointly with Total. Ato and Chloé have been merged into a single subsidiary, Atochem, that also combines parts of PCUK.

Rhône-Poulenc will attempt to fight its way back to profitability through greater emphasis on higher value-added specialties. It takes on PCUK's fine and inorganic chemicals, as well as Pharmuka, PCUK's pharmaceuticals company.

CdF Chimie, France's major fertilizer concern, is involved heavily with petrochemicals, plastics, and surface coatings. It receives the unsaturated polyester resins activities of the former Chloé and the remaining slice of PCUK that includes plastics and printing inks.

The chemical companies of France have been losing money heavily for several years and they hope the harmonization plans ultimately will reverse the trend. But the process will take some time. Meanwhile, the government is committed to injecting large sums of money, and it expects the companies themselves to initiate streamlinings that inevitably will entail cutting staffs.

This year, too, the Italians went far toward sorting out their chemical industry. Central to the operation, which has government backing, are Ente Nazionale Idrocarburi (ENI), the state-owned energy and hydrocarbons concern, and Montedison. The task was made all the more difficult by the several thousand workers involved, many hundreds of whom can't be kept on in the new structure.



Fiber production lags levels of late 1970s

a Estimates. **Source:** CIRFS (International Rayon & Synthetic Fibers Committee)

EniChem, ENI's new chemicals arm, has emerged as Italy's leading chemical company. It has taken over activities formerly run by ANIC, Liquichimica, Rumianca, and Societa Italiana Resine, together with a large slice of Montedison. The company also assumed whole ownership of Enoxy Chemical when Occidental Petroleum pulled out of the joint venture with ENI late last year.

The eight areas EniChem is engaged in are agricultural chemicals, basic chemicals, fine chemicals, detergent intermediates, pharmaceuticals, plastics and engineering polymers, synthetic fibers, and synthetic rubbers.

In petrochemicals, the company is responsible for all of Italy's lower olefins apart from one cracker Montedison has retained. This gives EniChem a nameplate ethylene capacity of about 2.2 billion lb. Products include elastomers and polyethylene, together with the necessary intermediates.

Although committed to improving efficiencies and maintaining production of bulk chemicals, there will be a push into the more profitable specialty areas. "Our objectives are to bring EniChem to net profitability by 1985," says vice president and general manager Italo Trapasso.

Speaking at the European Chemical Marketing Research Association's annual conference in Venice recently, Trapasso noted that in the past 12 months EniChem has closed or stopped construction of partially completed plants that could produce 2 billion lb of ethylene and 1.3 billion lb of plastics, mainly polyethylene and polyvinyl chloride, as well as several million pounds of other petrochemical products. These include acrylonitrile, aromatics, polyester staple fiber, and elastomers.

Italy's process of building a new, stronger petrochemical industry represents, in Trapasso's view, "one of the greatest reorganization challenges ever faced by the European chemical industry." He notes that since 1980, 49% of the country's ethylene capacity, 42% of low-density polyethylene, 29% of polyvinyl chloride, and 25% of high-density polyethylene capacity have been shut down.

Montedison management has been working assiduously to restructure in a drive to lift the company out of the red that it has been in for a number of years. Perhaps the most significant event this year is its linkup with Hercules, both in polypropylene and in health care products.

Polypropylene will be marketed worldwide through Himont, in which each partner has an equal stake. The marriage will benefit from Montedison's technical know-how in making the polymer using a third-generation catalyst developed jointly with Mitsui Petrochemical of Japan. The new Ziegler-Natta catalyst can slice 20% or more off production costs. Hercules' major contribution to the joint venture is its global marketing network.

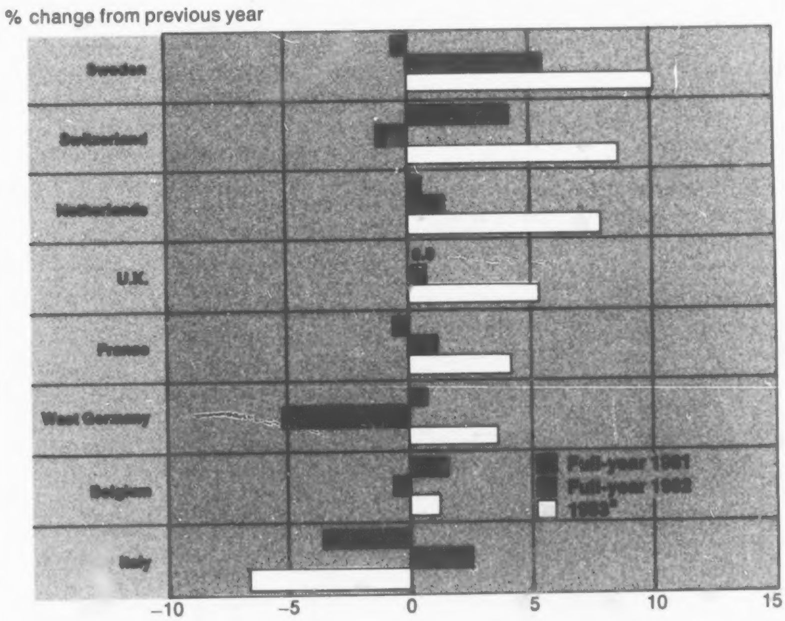
Both companies have pooled their manufacturing facilities, totaling 2.5 billion lb annually, making Himont the world's biggest polypropylene company. Himont also will absorb Neofil, the Italian-based Hercules/Montedison joint venture that manufactures polypropylene filament for carpets.

In the health care sector, Montedison has formed a new company, Erbamont, that consolidates its already considerable activities in pharmaceuticals. Erbamont has taken full title to Adria Laboratories, a Columbus, Ohio-based pharmaceutical company that Montedison had owned jointly with Hercules. In return, Hercules has a participation in Erbamont.

Also coming within the Erbamont fold are Kallestad Laboratories, which is headquartered in Austin, Tex., and active in the rapidly growing immuno diagnostics field, that Montedison acquired in July, and Lark Laboratories of New York City, a producer of bulk pharmaceutical products. Montedison sees these acquisitions as fundamental moves toward its becoming a primary factor in international pharmaceuticals markets.

While European chemical companies strive to improve their profitability, they are doing so against the background of a shaky economic climate. In its current annual economic report, the Commission of the European Communities plainly states that "the recovery remains slow and fragile in all respects. Some cyclical recovery in Europe is apparent, but it is patchy and on the whole weak, and is potentially vulnerable to any new adverse shocks from the international economy.

Chemical output on the upswing in most of Western Europe



a 1983 data are for first nine months for Switzerland, U.K., and Italy, for first eight months for Netherlands, France, and West Germany, and for first six months for Sweden and Belgium. **Source:** National chemical federations for each country

"There is now a communitywide effort to bring trends in public finance and wage costs under control. But the transformation of the adjustment process into the next dynamic phase of recovery is not yet evident on a wide or deep scale. In the Commission's judgment, the risks of relapse into continued quasi-stagnation are too great to let policies stand on the status quo."

Gross domestic product for the European Community grew a mere 0.5% this year. The increase was about the same as for 1982, and only half of what was forecast a year ago. For 1984, the commission looks for a 1.5% rise, but this might be optimistic. There are, of course, differences among the 10 member countries. The U.K. (up 2.8% this year) and Denmark (up 2.2%) fared best, whereas Luxembourg had a 2.4% fall in gross domestic product.

Inflation is lower for the fourth straight year. At 6.3%, it is well below the 11.1% high of 1980. Tough economic measures in West Germany and the Netherlands held it to around 3% there. In Italy, however, it is 15% this year and in Greece it tops 20%.

Unemployment continues to be a problem throughout EC. This year, the average edged beyond 10% of the working population for the first time, and unemployment may reach 11% in 1984. Ireland and the Netherlands have unemployment levels greater than 15%. Belgium isn't far behind at 14.5%.

In addition to coping with the uncertainties of a fragile Europe-wide economic situation, chemical company managers have another nagging concern. The time is fast approaching when they will face severe competition from Canada and the Middle East, both in Europe and in the areas elsewhere throughout the world to which they export. □

Japan

Chemical producers put hopes for revival on restructuring

Petrochemicals makers plan to cut excess capacity and form joint sales companies to avoid price wars

Earl V. Anderson, C&EN New York

Japan's chemical industry is crawling painfully out of the hole that it was pushed into by the country's lingering recession and the industry's own structural problems. Although this progress pleases chemical company executives, they aren't necessarily overjoyed.

Japan's economic recovery, which trails that in the U.S. by several months, has been relatively mild and is just starting to show signs of vigor. And the chemical industry, particularly in petrochemicals, has just begun a restructuring program that could take five years to complete.

The legal vehicle for restructuring is the Temporary Measures Law for Structural Adjustment of Specific Industries—commonly called the industrial structure law. It became effective in May, after a heated battle between the powerful Ministry of International Trade & Industry (MITI) and the Fair Trade Commission.

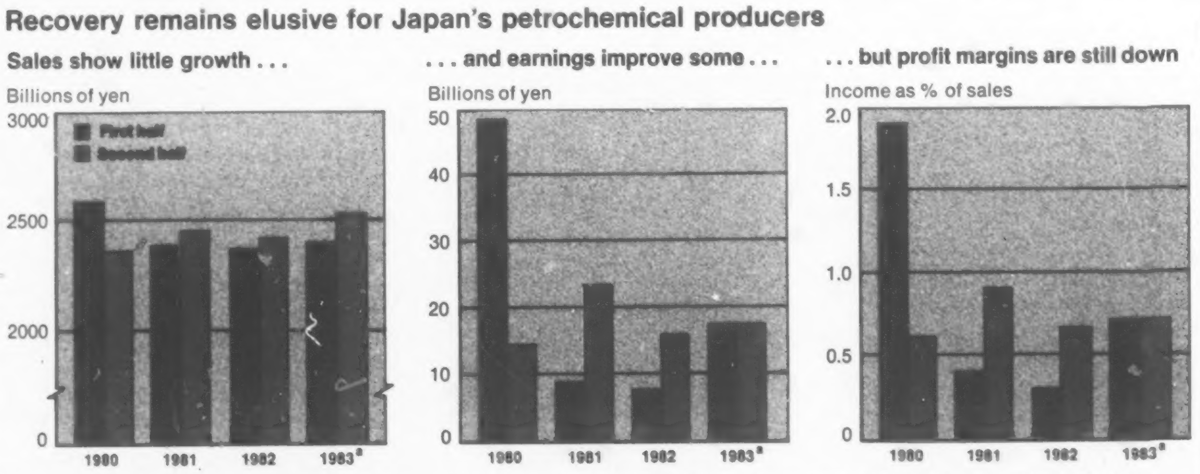
This new law replaces an older Specific Depressed Industries Law that expired in June. The old law was designed to see several depressed Japanese industries through troubles triggered by the first oil crisis 10 years ago. The idea was that these industries would be back on their feet by the time the law expired.

The second Iranian oil crisis disrupted this schedule. Not only did some industries covered under the old law fail to recover, but several others were added to the list of Japan's depressed industries, including petrochemicals, synthetic fibers, and fertilizers. And petrochemicals probably get the nod as the focal point of the new industrial structure law.

The new law makes it possible for companies within a specified industry to scrap excess capacity on a joint basis. They also are allowed to establish joint sales companies to avoid damaging price wars that result from too many companies chasing too small a market. These actions ordinarily would be illegal under Japan's Antimonopoly Act.

Petrochemical companies are adopting these two tactics enthusiastically. Plans are under way to cut ethylene capacity 36%, polyolefins capacity 22%, and polyvinyl chloride (PVC) capacity 24%. Joint sales arrangements are being established for various polyolefins and for PVC.

Ethylene and polyolefin plant-


Recovery remains elusive for Japan's petrochemical producers

[a] Estimated. **Note:** Data for fiscal years ending March 31. Based on results of 10 leading Japanese petrochemical companies: Mitsubishi Chemical Industries, Sumitomo Chemical, Asahi Chemical Industry, Toray Industries, Mitsui Toatsu Chemicals, Teijin, Showa Denko, Mitsubishi Petrochemical, Dainippon Ink & Chemicals, and Sekisui Chemical. **Source:** Toyo Keizai Shinposha

scrapping schedules have been set for some time. Recently, 21 PVC companies submitted plans to MITI for cutting their capacity. They hope to shut down plants that can make 450,000 metric tons per year—22% of the industry's total—by next February. The plants should be closed permanently by March 1985.

Ammonia producers, meanwhile, have just about completed scrapping 20%, or 660,000 metric tons, of their annual capacity. Urea capacity has been cut 35% or 810,000 metric tons per year. Other industry sectors, such as caustic-chlorine producers and styrene producers, still are considering whether to seek relief under the industrial structure law.

Planning for joint efforts to scrap excess capacity and to form joint sales companies is one thing. Putting these plans into action is more difficult. And it probably will become even more difficult as demand improves, as it now is doing for chemicals. Companies will want to get as much of the expanding market as they can for themselves.

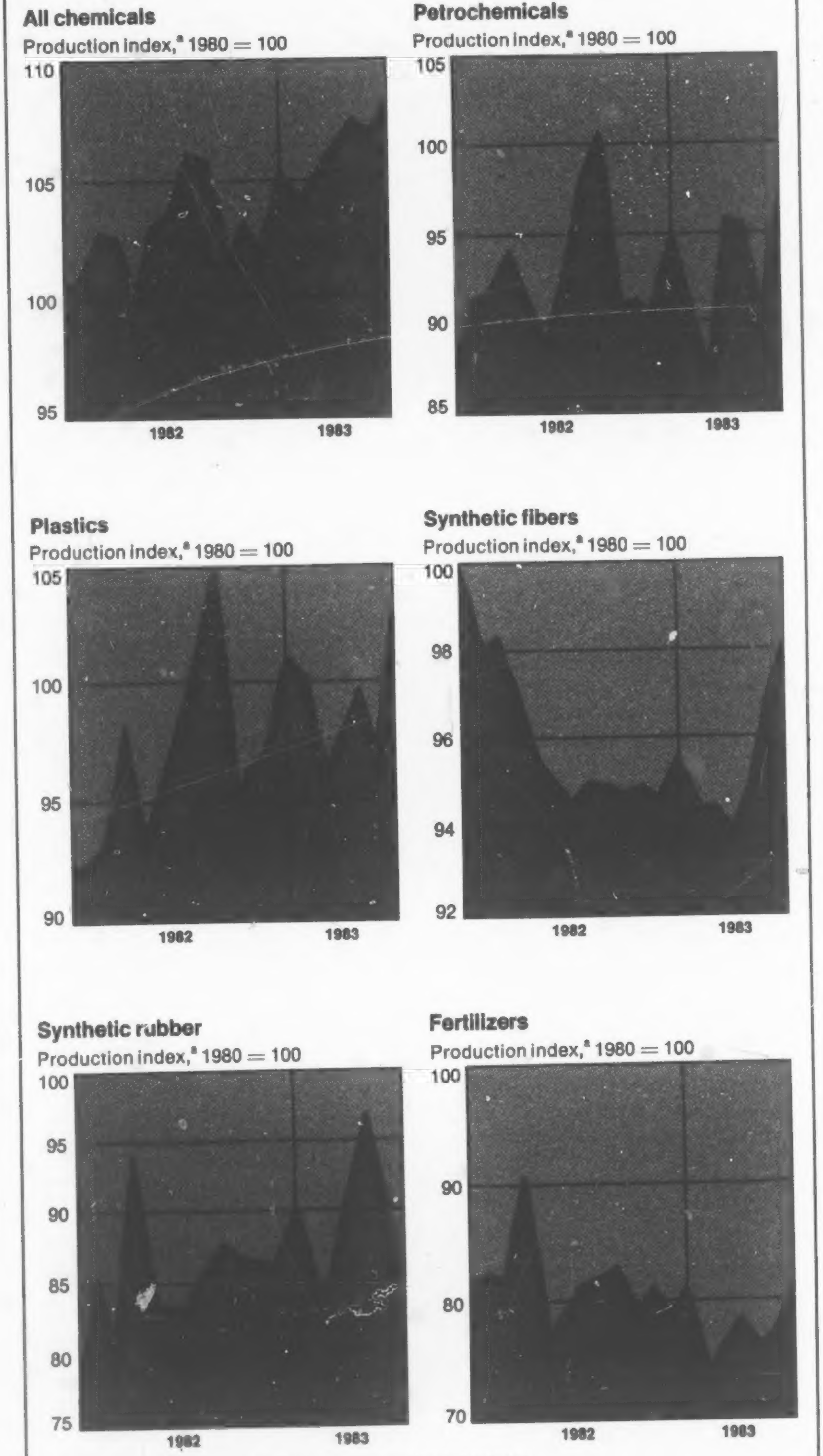
Yet, Japanese petrochemical companies seem sincere in their efforts. To make sure that the cartel plan is, indeed, implemented, the industry has devised its own penalty rule. If a company fails to scrap its agreed-upon capacity by the target date, it will be fined a penalty based on the annual capacity of the plant.

Meanwhile, chemical companies in Japan are enjoying the fresh breezes of economic recovery. Domestic demand is up; exports are increasing; and production is rising as a result. Growth in chemical imports has slowed. Prices of naphtha, the chief petrochemical feedstock in Japan, have leveled off, and Japanese companies have pushed through some much-needed price increases.

This beneficial combination is helping to put some black ink back in company financial statements. Although profits were depressed for the entire chemical industry during the first half of fiscal 1983 (March 1983 to September 1983), companies are expecting to do much better in the second half.

Many companies are revising their second-half earnings estimates upwards, sharply in some cases. And one recent industry survey, covering

Chemical production generally is edging higher this year



a Seasonally adjusted. **Source:** Ministry of International Trade & Industry the chemical industry as a whole, estimates that profits, which declined nearly 20% during the first half of fiscal 1983, will increase 76% during the second half. These figures are based on a comparison with the previous six-month periods. But what they indicate is that, when the fiscal year ends next March, chemical industry profits should be up nearly 50% from fiscal 1982.

Japanese chemical companies are benefiting as much, if not more, from the strong economic recovery in the U.S. as they are from the more tepid recovery in Japan. With demand improving in their own markets, U.S. chemical companies aren't pushing exports to Japan so hard as before. And with less competition from U.S. companies in Japan's important export markets in Southeast Asia, the country's exports are increasing once more.

Based on 10-month figures, Japan's chemical exports are expected to increase 7% this year to $6.8 billion. Imports, meanwhile, will inch ahead only 0.4% to $6.85 billion. Some trade analysts suggest that exports will be higher and that imports will be lower than these estimates. If they are right, Japan will regain a surplus in its chemical trade—a surplus that it lost last year.

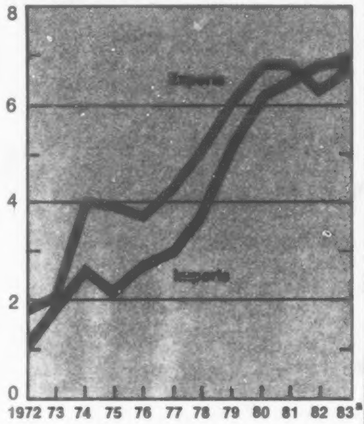
Chemical imports are a problem that won't go away entirely, however. Imports of ethylene dichloride, for example, hit record levels this year. Methanol imports from Saudi Arabia have started coming into Japan in large volumes and are certain to continue. These imports, along with some material from China, recently have raised total Japanese methanol imports to an average 100,000 metric tons per month.

Starting next February, Sumitomo Chemical plans to import propylene, butadiene, and benzene from Singapore when a petrochemical complex there comes on stream. Tariffs on some chemical products also will be lowered next year, ahead of schedule. And, over the long haul, much of the petrochemical production in Saudi Arabia will be earmarked for Japan.

Despite the improvement this year, Japan's chemical industry still has some problems to resolve before it can get into high gear. It may take several more years before the industry is lean enough to remain consistently in the black. □

Exports rebound to shrink the chemical trade deficit

Foreign trade in chemicals, $ billions



[a] C&EN estimates.
Source: Ministry of International Trade & Industry

Production gains are few and generally sluggish this year

Thousands of metric tons unless otherwise indicated	1982	Seven months 1983	Seven months 1982	% change
INORGANIC CHEMICALS				
Ammonium chloride	486	265	285	−7%
Ammonium sulfate	1689	985	999	−1
Calcium carbide	483	295	297	−1
Calcium superphosphate	527	343	317	8
Carbon black	504	319	299	7
Chlorine, liquid	794	472	474	0
Hydrochloric acid	551	296	326	−9
Nitrogen[a]	5236	3031	3071	−1
Oxygen[a]	6493	3653	3867	−6
Sodium carbonate	1162	670	669	0
Sodium hydroxide	2792	1622	1644	−1
Sodium silicate	650	339	376	−10
Sulfuric acid	6530	3863	3767	2
Titanium dioxide	184	116	108	7
ORGANIC CHEMICALS				
Acetaldehyde	279	137	168	−18
Acetic acid	353	171	206	−17
Acetone	229	137	126	9
Acrylonitrile	489	249	286	−13
Benzene[b]	1588	942	904	4
Butadiene	522	308	303	2
Butanol	234	126	129	−2
Caprolactam	388	227	234	−3
Cyclohexane	426	263	257	2
Dioctyl phthalate	221	128	127	1
Ethylene	3588	1952	2086	−6
Ethylene dichloride	1548	947	882	7
Ethylene glycol	385	191	213	−10
Ethylene oxide	471	257	268	−4
Methanol	625	249	416	−40
Octanol	226	116	123	−6
Phenol	211	145	111	31
Phthalic anhydride[b]	159	96	99	−3
Propylene[c]	2545	1490	1443	3
Propylene glycol	185	108	106	2
Styrene	1086	604	605	0
Terephthalic acid	649	408	362	13
Toluene	803	477	469	2
Toluene diisocyanate	67	40	35	14
Xylene	1225	740	698	6
Urea	1187	606	702	−14
PLASTICS				
Phenolic resins	281	170	164	4
Polyethylene	1674	931	981	−5
Polypropylene	941	600	531	13
Polystyrene	1190	708	679	4
Polyvinyl chloride	1218	773	668	16
SYNTHETIC RUBBER	931	564	537	5

a Millions of cubic meters. b Petroleum-based product only. **Source:** Ministry of International Trade & Industry

Canada

Business is better but feedstock costs cause concern

Petrochemical producers worry that government tax and pricing policies will cut them out of world markets

Earl V. Anderson, C&EN New York

Canadian chemical leaders are keeping one eye glued to their financial statements to convince themselves that the recovery they see is no mirage. As the year winds down, chemical production continues to bounce back from 1982's depressed levels. Sales and profits are improving. Some, if not all, expansion plans are being put back on the front burner.

Other focus, meanwhile, will be on Ottawa. By the end of the year, if the deadline is met, a blue ribbon task force will complete its detailed study of Canada's petrochemical future and submit its recommendations to the federal government.

Cynics point out that this is the third major study of the Canadian petrochemical industry in five years. But few are taking it lightly. The study is seen as a golden opportunity to get across to government officials just what it will take to assure the long-term future of both the natural gas-based petrochemical industry in Alberta and the oil-based industry centered in Sarnia, Ont., and Montreal, Que.

More important, of course, will be how the federal government acts upon whatever recommendations are made. The industry will be watching closely for these reactions next year.

It's difficult to conceive of the task force's avoiding the politically sensitive issue of the National Energy Program (NEP) and its impact upon petrochemical feedstock prices. W. Norman Kissick, president and chief operating officer of Union Carbide Canada—and a member of the petrochemical task force—says that the impact of NEP has been especially destructive. The industry now wonders, says Kissick, if it is going to be taxed out of existence.

In 1981, the Canadian petrochemical industry earned $345 million (Canadian) before taxes. In 1982, it lost $244 million—"a $600 million turn for the worse in one year," Kissick calls it.

True, the recession, both in Canada and in other countries where Canadian chemical exports took a beating, helped cause the collapse in Canadian chemical company fortunes. But many industry executives think that a more realistic taxation policy could have made the recession's impact less severe.

One part of the problem is the upfront taxes that Canadian petrochemical producers must pay for feedstock. Kissick estimates that these taxes represent 76% of the total for oil and 57% for natural gas.

The other part of the feedstock pricing problem is that Canadian oil and gas prices have been escalating while international prices have been declining. Canadians now pay about 98% of world prices for their oil, compared to the 85% ceiling that was promised originally under NEP. And, says A. E. Egglestone, senior vice president of Alberta Gas Chemicals Ltd., natural gas prices have doubled in two years.

Canada is no longer one of the low-cost-gas nations of the world, says Egglestone. Prices may be low compared to those in the U.S. But Egglestone thinks that the U.S. is no longer in competition for world

Output rebounds, but not to earlier levels for many chemicals

Thousands of metric tons	1983[a]	1982	1981	1980	1979	1978
Ammonia	2760	2509	2654	2555	2405	2398
Ammonium nitrate	915	1018	1212	873	914	871
Ammonium phosphate	1140	888	1355	1466	1336	1178
Benzene	560	504	571	604	492	555
Chlorine	1330	1233	1292	1303	1031	941
Ethylene	1200	1013	1330	1184	1014	826
Hydrochloric acid, 100%	155	135	186	177	154	155
Phosphoric acid, 100% P_2O_5	570	503	744	808	748	554
Polyethylene	590	571	633	641	628	478
Polypropylene	660	618	671	590	na	na
Polyvinyl chloride	240	194	222	190	145	125
Sodium chlorate	290	264	255	245	224	199
Sodium hydroxide	1470	1367	1458	1459	1138	1036
Sulfuric acid	3410	3131	4117	4295	3666	3261
Urea	1365	1231	1303	1274	1212	1217

a C&EN estimates. na = not available. **Source:** Statistics Canada petrochemical markets. He says that Canadian governments, both federal and provincial, have "outtaxed and outpriced Canadian natural gas" to the point that new gas-based petrochemical plants are no longer competitive in world markets.

Obviously, the hydrocarbon taxation and pricing issue will be an important one in the coming year. It also figures to be a thorny one, because it touches many politically sensitive nerves.

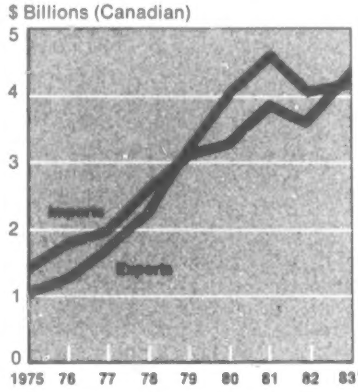
Meanwhile, even without a change in feedstock price and tax policies, the Canadian chemical industry is recovering from the 1982 recession. The upturn that started early in 1983 became even stronger as the year progressed.

Output of ethylene, for instance, will total about 1.2 million metric tons, 18% higher than last year, reflecting increased demand for its derivatives. Although total polyethylene production will increase only about 3%, other derivatives are faring much better.

Polyvinyl chloride (PVC) is a good example. For the year, PVC output probably will be 240,000 metric tons—24% higher than last year.

This means that PVC production will be higher than ever before. PVC is benefiting from a recovery in Canadian auto and housing markets, and an Esso Chemical Canada expansion this year at Sarnia, Ont., has helped the supply picture.

Exports rise, but deficit returns to chemical trade



a C&EN estimates. **Source:** Statistics Canada

Even in the less glamorous, but important inorganic chemicals segment of the industry, business is perking up. Output of sulfuric acid, which had been sluggish for most of the year, gathered momentum in the third quarter as demand at smelters increased. Hydrochloric acid production, thanks in part to exports to the U.S., will be 15% higher in 1983 than it was last year. Caustic soda and chlorine production both will be about 8% ahead of last year, again because of brisk export sales this year.

These higher production rates, and the higher-volume sales that they imply, are having a favorable impact on chemical company balance sheets. The combined nine-month sales of the four major publicly reporting companies, C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide Canada, increased 5% to $2.5 billion this year.

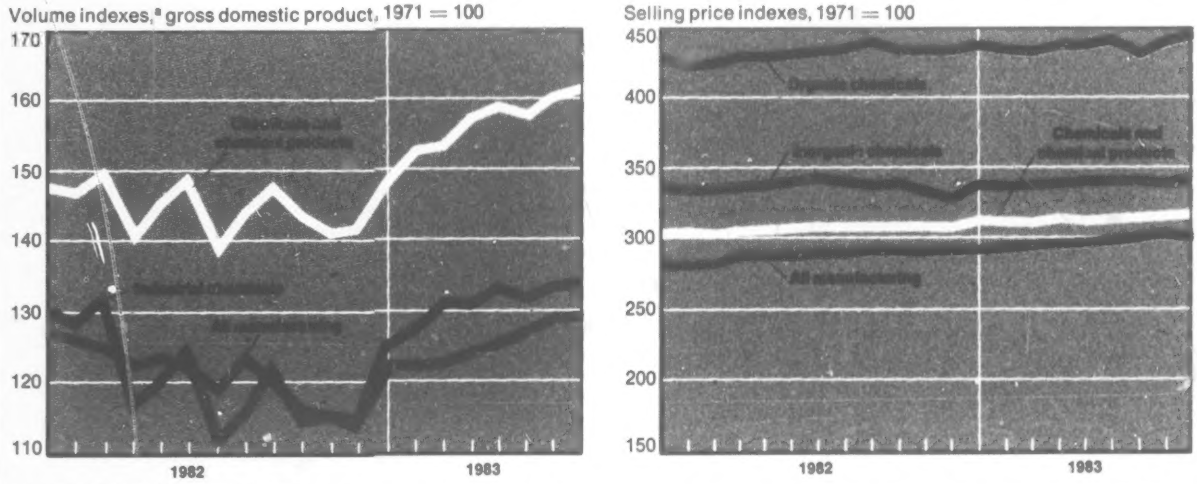
Just as important, if not more so, net income for the period was $42.4 million. That may not represent much of a profit margin, but compared to the $10.4 million loss of last year, it is a welcome improvement.

Nevertheless, export sales, particularly of petrochemicals, still are hard to come by. Through the first nine months, Du Pont Canada's export sales were off 8%. And Union Carbide Canada, which reported that domestic sales were up 13%, suffered a 46% decline in export business.

As a result, Canada will return to its traditional foreign trade deficit in chemicals this year. The country's chemical trade shifted into a surplus in 1979 and maintained that surplus through last year. This year, however, chemical exports probably will increase only 3% to $4.2 billion, while Canada's revived economy pulls in 20% more ($4.3 billion) in chemical imports than in 1982.

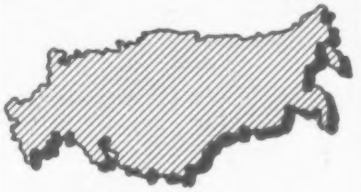
This is a situation that the Canadian chemical industry hopes to reverse once again next year. And it hopes that a more realistic government policy toward petrochemical feedstocks will emerge to make the task easier. □

Recovery takes hold for chemical makers . . . . . . but they find that price hikes come hard



a Seasonally adjusted. **Source:** Statistics Canada

U.S.S.R./Eastern Europe



Slow growth continues in Soviet Union and East Europe

Andropov unlikely to make basic reforms in economic system needed to get chemical and other industries moving again

Richard J. Seltzer, C&EN Washington

When Yuri Andropov succeeded Leonid Brezhnev a little over a year ago as Soviet leader, many western analysts placed the Soviet Union at a major turning point comparable to the post-Lenin and post-Stalin periods. The analysts pointed to a host of unresolved problems and issues. Economic and industrial growth rates were falling. Decisions were growing difficult on allocation of resources between military and civilian needs. There was an increasing burden from the stagnating economies of the East European members of the Council for Mutual Economic Assistance (CMEA)—Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania.

Many observers viewed the choosing of Andropov as aimed at tackling these problems—installing a strong leader to get the country moving again, and with it all of East Europe. Indeed, Andropov began by openly acknowledging the U.S.S.R.'s economic problems and calling for steps to correct them. Western analysts speculated that he might undertake some of the fundamental structural reforms they believe necessary to solve Soviet economic and industrial problems—for example, introducing into the central planning system a measure of decentralization and market incentives, such as Hungary is trying.

However, some western analysts now say, Andropov's rule is likely to amount to a "transition period," rather than a time of initiating new conditions, even if Andropov should recover sufficiently from his recent illness to maintain his leadership for quite some time to come. His approach has been to crack down on worker discipline and on corruption, trying to make the existing system work better, rather than seeking structural changes that might threaten loss of political control by party and government bureaucracies. Thus, any steps toward solution of the basic problems apparently must await new leadership. In the meantime, the region's economies will continue to limp along.

This, indeed, is what appears to be happening. Information is always sparse about Soviet and East European economic goals and results, and western analysts always doubt the reliability of official statistics. This year, even less information is available: Apparently because of Andropov's illness, the Soviets have postponed from November to the end of December the annual meetings of the Communist Party Central Committee and the Supreme Soviet (the nominal Soviet parliament).

However, the Soviet and East European economies and industries generally show slow or no growth this year, and the same is likely next year, continuing the pattern of slower growth that began in 1979. Even the modest goals of their current five-year plans (1981–85) generally are not being met.

Real gross national product for the six East European CMEA members declined in 1982 for the third year in a row (down 0.2%, compared to drops of 1.0% in 1981 and 0.1% in 1980), according to Central Intelligence Agency calculations. (CIA figures generally are lower than official Soviet statistics, because the agency tries to eliminate double counting, disguised inflation, and other upward biases.) The goal was a relatively modest 2.4% increase. By contrast, gross national product for the six nations rose 4.7% a year from 1971 to 1975. The regional average in 1982 was particularly depressed by Poland's decline of 4.0%.

Soviet gross national product grew just 2.0% in 1982, compared to a goal of 3.0%. This was less than half the growth rates from 1971 to 1977, and follows increases of only 0.4% in 1979, 1.7% in 1980, and 2.2% in 1981. Growth is expected to be about 2% again this year (the goal was 3.3%).

Industrial production for the region also is growing at a slower pace. Overall, industrial output for the six CMEA members rose just 0.7% in 1982, after a drop of 2.0% in 1981, according to CIA estimates (the target was a 2.8% gain). A drop of 3.9% in Poland's output lowered the average somewhat, but the average of the other five nations also shows slowing growth. The six-nation goal for 1983, a 4.1% increase, is unlikely to be met.

The U.S.S.R.'s industrial production rose just 2.5% in 1982, according to CIA figures, only half the goal of 4.7% or the average annual growth, also 4.7%, set by the five-year plan. The goal for 1983 is a modest 3.2%, showing that the Soviets already have abandoned hope of fulfilling the plan's target.

Chemical and rubber production slowed in 1981 and 1982 in most East European countries, according to official figures. In Czechoslovakia, it dropped 0.3% in 1982 (the target was 5.1 to 5.9% average annual growth in 1981–85). In 1981, Czech output rose only 2% compared to an average increase of 6% a year in the five previous years. Bulgaria's output rose just 1% in 1982 (compared to a target of nearly 8% a year for 1981 to 1985 and gains of 4% in 1981 and 11% in 1980). And Hungary's production was up just 2% in 1982 (output rose about 6% a year from 1976 to 1980).

Soviet chemical and rubber output was up just 3% last year, only half the target for yearly growth between 1981 and 1985. It also was only a bit more than half the increases registered in 1981 and 1980, and far below the 7 to 10% yearly growth rates of the early 1970s.

This year, through October, Soviet chemical production is again up just 3%, compared to the same period last year. However, output of several chemicals has rebounded from slow growth or declines last year. For instance, plastics are up 8%, versus a drop of 1% last year, and output of sulfuric acid is up 4%, chemical fibers and yarns 7%, and mineral fertilizers 10%. Thus, the Soviets apparently will exceed their goals this year for growth of 5% in output of fertilizers and come close to the 9% goals for plastics and fibers.

The slowdown in the East European chemical industry occurs within a general framework of cutbacks in capital investment and imports, reflecting concern to reduce foreign debt. A major factor in the chemical slowdown—as in other energy- and material-intensive industries—is declining domestic production of energy and raw materials, with limited possibilities for imported substitutes. For example, several sources report cuts of 10% in crude oil imports by East European countries from the U.S.S.R., which produces 98% of the region's oil. The Soviet Union has raised its oil prices within CMEA and is trying to conserve oil for use predominantly as a raw material by processing industries while increasing the share of coal and natural gas in the fuel supply.

Another reason for the slowdown is that restructuring of the chemical industry is being given priority over expansion of existing production. A general aim is to increase output of plastics, synthetic fibers, pharmaceuticals, and cosmetics. Much attention also is devoted to automation, electronics, and more effective use of resources and energy. □

Growth stronger for chemicals in Soviet Union this year

Thousands of metric tons unless otherwise indicated	10 months 1983	1982	1981	1980
Mineral fertilizers[a]	24,600	26,700	25,990	24,760
% change from previous year	10%	3%	5%	12%
Nitrogen (N)	na	11,200	10,705	10,241
% change from previous year	na	5%	5%	12%
Phosphate (P_2O_5)[b]	na	7,200	6,836	6,455
% change from previous year	na	5%	6%	2%
Potassium (K_2O)	na	8,300	8,449	8,064
% change from previous year	na	−2%	5%	21%
Sulfuric acid	20,400	23,800	24,095	23,033
% change from previous year	4%	−1%	5%	3%
Ammonia[c]	na	15,400	14,718	13,762
% change from previous year	na	5%	7%	12%
Plastics[d]	3,600	4,057	4,089	3,637
% change from previous year	8%	−1%	12%	5%
Sodium hydroxide	2,400	2,783	2,757	2,755
% change from previous year	2%	1%	0%	3%
Synthetic rubber	na	1,815	1,860	1,880
% change from previous year	na	−2%	−1%	1%
Chemical fibers and yarns[e]	1,100	1,229	1,218	1,200
% change from previous year	7%	1%	1%	8%
Pesticides	465	533	504	474
% change from previous year	5%	6%	6%	0%

a Nutrient content basis; includes some products used for technical purposes. b Includes ground phosphate rock for direct application and phosphate animals feeds. c Nitrogen content basis. d Includes resins for synthetic fibers. e Excludes olefins and textile glass. na = not available. **Sources:** Central Intelligence Agency, Department of Commerce, Textile Economics Bureau

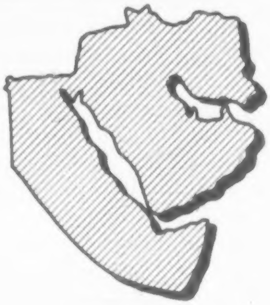
Output slumps for much of East Europe's chemical industry

Thousands of metric tons in 1982, unless otherwise noted	Bulgaria	Czechoslovakia	East Germany	Hungary	Poland	Romania	Total
Mineral fertilizers[a]	999	na	4668	na	2283	2700	na
% change from 1981	−1%	na	−2%	na	2%	2%	na
Nitrogen (N)	760	567	948	571	1297	na	na
% change from 1981	1%	5%	−2%	−3%	2%	na	na
Phosphate (P_2O_5)	239	335[b]	286[b]	155	868	na	na
% change from 1981	−7%	−1%	−21%	−2%	0%	na	na
Potassium (K_2O)	—	na	3434	na	118[c]	na	na
% change from 1981	—	na	−1%	na	16%	na	na
Sulfuric acid	892	1252	920	600	2682	1600	7946
% change from 1981	−3%	−5%	−3%	10%	−3%	−12%	−4%
Plastics	325	956	990	326	438	na	na
% change from 1981	12%	5%	−1%	4%	−8%	na	na
Sodium hydroxide	155	315	695	178[d]	363	na	na
% change from 1981	3%	−4%	10%	−1%	−9%	na	na
Synthetic rubber	30	65	155	—	100	160	510
% change from 1981	0%	3%	0%	—	−10%	10%	1%
Chemical fibers and yarns[e]	90	157	292	28	193	214	974
% change from 1981	−5%	9%	−4%	−4%	5%	−2%	0%

a Nutrient content basis. b Including production of ground phosphate rock for direct application and phosphate animal feeds. c Imported potash added to domestically produced nitrogen and phosphate to form multinutrient fertilizer. d Including regenerated sodium hydroxide. e Excluding olefins and textile glass. na = not available. **Sources:** Central Intelligence Agency, Textile Economics Bureau, United Nations Economic Commission for Europe

Middle East

New chemical complexes are beginning to come on stream



Saudi Arabia started up two plants this year and has six more planned this year and next

Dermot A. O'Sullivan, C&EN London
Richard J. Seltzer, C&EN Washington

This year saw startup of two of the clutch of Saudi Arabia's new chemical plants. A methanol unit came on stream in February, followed a few weeks later by a fertilizer complex. Routine deliveries outside the country are under way.

Methanol is being produced by Saudi Methanol, a company jointly owned by Saudi Basic Industries Corp. (SABIC) and a consortium of Japanese firms, in a plant with an annual capacity of 1.3 billion lb. Ammonia (725 million lb annual capacity) and urea (1.2 billion lb) are made by Al-Jubail Fertilizer Co., in which SABIC is linked with Taiwan Fertilizer Co. Both operations are at Al-Jubail, the emerging industrial center in the east of the country.

That the plants were on schedule and within budget puts the lie to the opinion held until recently that it would be extremely difficult to establish sophisticated chemical operations in the harsh Saudi environment and find the skilled technicians to run them. It served also as a stark reminder to managers in Europe, the U.S., and elsewhere that the time is fast approaching when other petrochemicals from Al-Jubail and from Yanbu, in the west, will be traded internationally.

Next year and the year following will see startup of six major complexes. All told, their rated annual capacity will be 3.5 billion lb of ethylene, 1.4 billion lb of additional methanol, 1.3 billion lb of linear-low-density polyethylene, 1.1 billion lb of ethylene glycol, 650 million lb of styrene, 620 million lb of ethanol, and 200 million lb of high-density polyethylene, not counting such intermediates as caustic soda and ethylene dichloride. SABIC is involved in all of them. Its partners in the various companies include Celanese, Exxon Chemical, Mobil Chemical, Shell Oil, and Texas Eastern.

Nor will expansion stop there. Planned are 660 million lb-a-year vinyl chloride and 440 million lb-a-year polyvinyl chloride units, and possibly one for making 155 million lb a year of polystyrene. Other projects entail annual capacity of 1.3 billion lb of ammonia, 1.1 billion lb of methyl *tert*-butyl ether, 275 million lb of butadiene, 175 million lb of butene-1, and 90 million lb of polyisoprene.

Some of the output, of course, will be used domestically. Low domestic consumption figures point to plenty of room for local growth. But much of it is slated for world markets.

Because of the sheer scale of developments in Saudi Arabia, it's easy to overlook events elsewhere in the Middle East. But moves have been under way in other countries of the region that also will lead to increased chemical output and exports.

In Iran, for instance, there was a revival late this year of plans for the massive chemical complex at Bandar Khomeini, a joint venture of National Iranian Oil Co. and a consortium of Japanese companies. The Iranians bowed to demands to pay $55 million that the Japanese claimed was owed them, thereby clearing the way to move ahead with the project.

A range of products will be made there, centering on a 660 million lb-a-year ethylene cracker and a 1.1 billion lb-a-year aromatics unit. The complex, 85% complete before it was stalled by the war between Iraq and Iran, has been hit in a number of bombing raids. Although originally slated to be completed last year, it now is more likely that the final phase of construction will be withheld until the war is ended.

Israel, meanwhile, faces what many observers call its most severe economic crisis. Inflation exceeds 150%; industrial production, gross national product (in constant prices), and exports are static or declining; and the trade deficit and external debt are soaring. The government has responded with an "export-oriented austerity policy," involving a 7 to 9% cut in the standard of living, heavy cutbacks in government domestic spending, and intensive efforts to promote exports and reduce imports.

Priority will go to high-technology industries. The chemical industry (including rubber, plastics, and mineral products) accounts for almost a third of industrial production and of industrial exports (excluding processed diamonds). Chemical exports totaled just over $1 billion in 1980 and 1981, but dropped to $958 million in 1982 with the world recession and declining currency values in Western Europe. Through October this year, chemical exports rose 3% and total industrial exports dropped 5%. □

Mexico

Demand for chemicals sags as Mexico fights financial crisis

Austerity measures have stalled chemical growth but investment in petrochemicals continues to have high priority

Earl V. Anderson, C&EN New York

The Mexican chemical industry, like most Mexican industries, is suffering through a dismal year. Faced with Mexico's worst financial crisis in decades, President Miguel de la Madrid Hurtado, who took office a year ago at the height of the financial storm, implemented some tough economic measures to keep the country from defaulting on its $80 billion foreign debt.

These measures won him plaudits from the international financial community, but they brought to a screeching halt the overheated, oil-fed economic growth to which Mexicans had become accustomed. Mexico's chemical industry felt the impact.

Growth in the domestic market, which had been averaging 10% annually for several years, slipped to 2 to 3% in 1982. This year, domestic demand for chemicals probably will be down 5 to 10%, depending upon the sector of the chemical industry.

With little or no foreign exchange available, imports of sorely needed raw materials and equipment have dried up. Investment has dwindled. Financial crises are a common problem among chemical companies.

Even within Mexico, raw material supplies are a problem. Many privately held companies in the secondary petrochemical industry complain about uncertain and inadequate shipments of raw materials from Petróleos Mexicanos (Pemex), the government-owned petroleum company that has sole jurisdiction over primary petrochemical output in Mexico.

However, the mood among chemical industry leaders is not to dwell on past and present problems, but to plan ahead for a resumption of growth. One vital factor is on their side. In Mexico, the petrochemical industry is considered a priority industry.

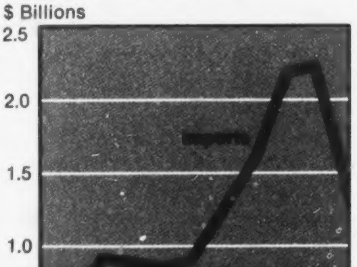
Government leaders stress repeatedly that Pemex's huge investments in petrochemical plants will continue, although the company will be more selective in deciding which investments come first. Meanwhile, the government has high hopes that its petrochemical industry can become not only less dependent on imports but a significant exporter as well, earning much-needed foreign exchange.

A trend to watch in Mexico is the extent to which private companies in the secondary chemical industry will be able to help plan future investments in the public petrochemical sector. There's no doubt that these companies want to be consulted when public investment and even regulations that affect the chemical industry are considered. They feel that cooperation between the two is vital.

Apparently, the government feels the same way. It has asked ANIQ (the Mexican Chemical Industry Association) to form a consulting committee to mesh with government agencies on both primary and secondary petrochemical matters.

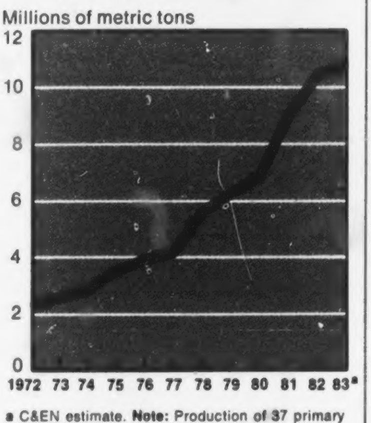
If this cooperative mood survives, industry leaders feel they can lay the groundwork for solid medium- and long-term growth. Meanwhile, they will be happy if next year brings them even a 2 to 4% increase in domestic sales. ☐

Imports of chemicals nosedived last year



Source: Asociación Nacional de la Industria Química (ANIQ)

Growth in output slows for basic petrochemicals



a C&EN estimate. **Note:** Production of 37 primary petrochemicals produced exclusively by Petróleos Mexicanos (Pemex). **Source:** Pemex

Brazil brings chemical foreign trade into balance

Although domestic demand is stagnant, exports are up sharply and imports have been strongly curtailed

Earl V. Anderson, C&EN New York

"The (Brazilian) chemical industry has a reputation of being the bad little boy that imports," says Carlos Mariani Bittencourt, president of Abiquim (Associação Brasileira da Indústria Química e de Produtos Derivados), the Brazilian chemical industry's trade association. "But this year, we are bringing our exports and imports into balance."

Mariani is right, of course, and it gives him and everyone else associated with the Brazilian chemical industry a lot of pleasure to get the upper hand over the industry's detractors. With Brazil's $90 billion debt raising havoc with the country's economy, imports that drain precious foreign exchange are not particularly popular—especially imports of crude oil from which price-subsidized naphtha is produced for petrochemical feedstock.

But for Brazil's chemical industry in general, and for the petrochemical industry in particular, the two rules of the day are import substitution and export expansion. Import substitution is nothing new to Brazil. It has helped to fuel Brazil's economic miracle of the past two decades that ended with the country's liquidity crisis. Now, import substitution is getting a boost from that crisis.

Until a few years ago, import substitution wasn't part of the chemical industry's game plan. In 1980, for instance, chemical imports hit $3.1 billion and gave Brazil a chemical trade deficit of $2.6 billion.

Since then, chemical imports have dropped rapidly—to $2 billion in 1981 and $1.8 billion last year. This year, Abiquim estimates, chemical imports will plunge 34% to only $1.2 billion.

On the other side of the coin, chemical exports have climbed sharply since 1980. In 1981, they jumped 67% to $924 million before sliding back to $839 million during the 1982 world recession. This year, Brazil's chemical exports are bouncing back with a vengeance. Abiquim expects them to reach $1.2 billion, matching chemical imports and erasing the country's chemical trade deficit. Government statistics through the third quarter indicate that this could, indeed, happen.

Next year, if developments pan out as expected, Brazil will have a chemical trade surplus for the first time. It no doubt will be small, but it will be a milestone nonetheless.

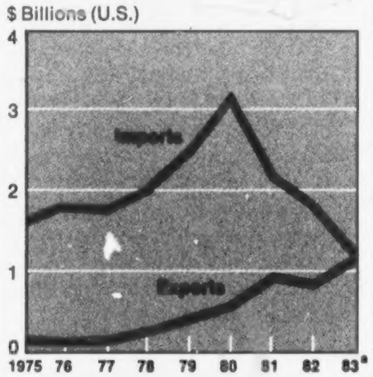
Despite the pleasant ring to all of this, all is not well with Brazil's chemical industry. Much of the heralded import substitution in the chemical industry is by government fiat, not by choice. The result is that many firms are short of raw materials needed to run their plants.

And chemical exports are increasing primarily because they are the only alternative to a stagnant domestic market. There was considerable overcapacity in Brazil's chemical industry even before the new, southern petrochemical complex came on stream early this year at Porto Alegre in Rio Grande do Sul. The domestic chemical market probably will shrink 6 to 7% this year. Meanwhile, chemical production is likely to be 25% greater than the domestic market will absorb. This is the material that will be earmarked for exports, which could jump more than 40% this year.

It is this export effort, and certainly not the domestic market, that explains why Brazil's output of ethylene was running 18% higher than last year midway through the year, and why production of plastics ranged from 11 to 44% higher. With the exception of ammonia, gains such as these are confined to the petrochemical sector. Inorganics aren't faring nearly so well.

There's very little optimism among chemical industry leaders about domestic chemical demand in 1984. This means that the only course available to the industry in 1984 is more of the same—substitute for imports and push exports hard. ☐

Brazil finally balances its chemical trade



a C&EN estimate. **Source:** Associação Brasileira da Indústria Química e de Produtos Derivados

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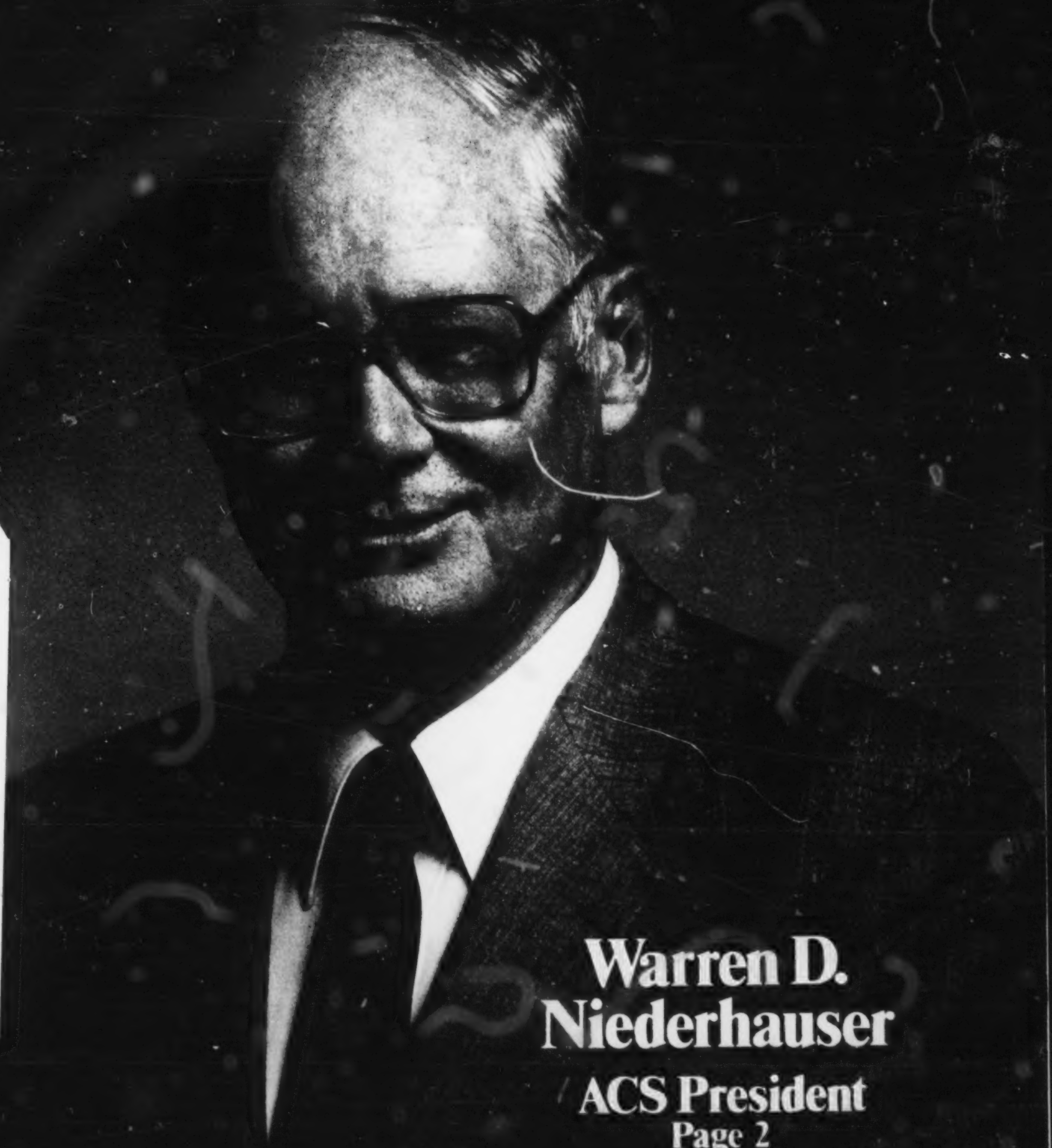

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- **Ellis K. Fields wins runoff election for 1984 ACS president-elect. Page 7**
- **EPA will review butadiene data to determine if use of and exposure to the chemical should be regulated under TSCA. Page 7**
- **Allied will sell its liquid fertilizer business to AAC Holdings. Page 7**

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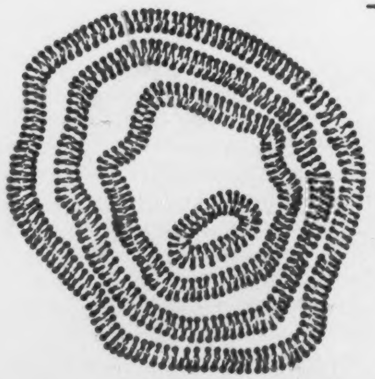


Special Report

Membrane mimetic chemistry shows promise in controlling rates of reactions, targeting drug delivery systems. Page 25

R & D FUNDING OUTLOOK: Battelle forecasts 9% rise in 1984

Research and development in the U.S. again will be funded generously in 1984, with industry sponsors continuing to provide the largest increases. Expenditures for U.S. R&D will be about $94.2 billion in 1984, Battelle Memorial Institute's Columbus division says in its annual R&D forecast. According to Battelle economists Jules J. Duga and W. Halder Fisher, that sum will be up 8.9% over the $86.5 billion the National Science Foundation estimates for R&D in 1983.

The Battelle forecasters expect that inflation in R&D costs will be only 5% in 1984. If that assumption holds true, real growth in R&D will be about 3.7%, slightly higher than the 10-year average annual increase of 3.3%.

Industry will continue to outpace the federal government in R&D support. Industry is expected to provide $48.8 billion, a 10.3% increase from 1983 and 51.8% of the total. Federal government funds for R&D will rise 7.8% to $42.7 billion, or 45.3% of the total. Academic institutions will account for $1.7 billion, or 1.8% of the total. Funding by other not-for-profit organizations will drop slightly, to just under $1 billion, 1.1% of the total.

During the past 10 years, Battelle notes, industrial R&D support grew at a compound annual rate of 5.2%, but federal support increased, on average, only 2.9%. Part of next year's increase in industrial R&D can be attributed to the improving economy. But another factor is the "relaxation of real and perceived barriers to cooperative research." This has encouraged multicompany-supported R&D programs at universities and not-for-profit organizations, Battelle says, and also has led to the creation of dedicated research centers supported by groups of firms.

As usual, industry will do most of the work. For 1984, performance of R&D by industry will rise to $70.8 billion, or 75.2% of the total (compared to 72.5% in 1983). In-house federal research will amount to $10.3 billion (10.9% of the total). R&D by academic institutions will account for $10.5 billion (11.1%). R&D by other not-for-profits will come to $2.6 billion (2.8%).

Four government agencies (Department of Defense, National Aeronautics & Space Administration, Department of Energy, and Department of Health & Human Services) will account for 90.9% of the total federal R&D funding in 1984—not much change from 1983, Battelle says. However, the apportionment among these four will change significantly.

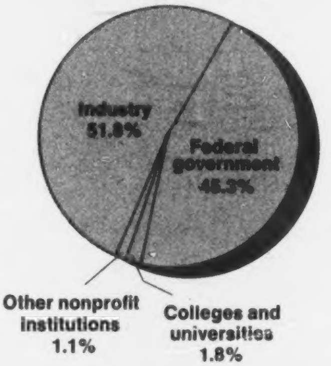
DOD will fund 64.5% of the federal total, compared to 58.9% in 1983, with the increase directed mainly toward the acquisition of major weapons systems. NASA's share of the total will decline to 7.0% from 8.2% in 1983. Although the space shuttle's success will justify continued support, much of that support will be transferred from R&D to operational programs, Battelle notes. Energy R&D funding also will decline, except for defense-related programs. DOE will account for 9.9% of the total, compared to 11.7% in 1983. Similarly, HHS will account for 9.5%, compared to 11.0% in 1983.

Thanks to the re-emphasis of defense, the aerospace industry will regain its former pre-eminence in industrial R&D, with funding of more than $15.8 billion (72.9% federally funded). Last year's leader, the electrical machinery and communications industry, will come in a strong second, with $14.5 billion (39.3% federally funded).

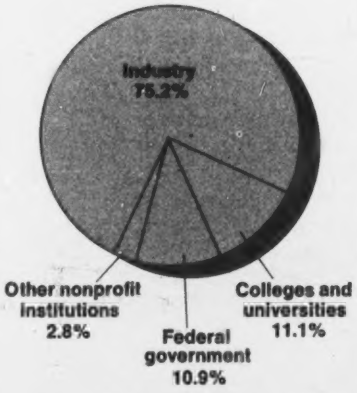
Other major sectors of industrial R&D include machinery ($9.1 billion), chemicals ($8.2 billion), autos and other transportation equipment ($6.2 billion), professional and scientific instruments ($5.8 billion), petroleum products ($2.9 billion), and food and beverage products ($1.0 billion). The total for all manufacturing industries will come to $68.5 billion, with 68.2% from the industries and 31.8% from the federal government. □

R&D funding to reach $94.2 billion in 1984

Source of funds



Performance of R&D



Source: Battelle Columbus Laboratories

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JANUARY 9, 1984

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YELLOW RAIN

The strange case of the Hmong

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Cover: Photo by Jacqui Chagnon

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- **GAF expects revamp of chemical and building materials divisions to boost profits substantially.** **Page 5**
- **Allied simplifies processes to manufacture silicon tetrafluoride and silane.** **Page 5**
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Chemical companies' traditional postrecession liquidity buildup squeezed by increasing debts despite cash gains. **Page 36**

Government

Department of Energy completes its plan for radioactive waste management mandated by Congress in 1982 act. **Page 39**

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Nobelist Henry Taube tells of his research in inorganic oxidation-reduction reactions that led to the chemistry prize. **Page 43**

Books

"The Scientist and Engineer in Court" views the expert witness's role as advocative rather than scientifically objective. **Page 45**

News Focus

Scientific support for the charge that the Soviet Union is involved in the use of "yellow rain" toxin weapons is weak. **Page 8**

- The government claims it has eyewitness reports and extensive intelligence data to substantiate its case
- But the difficulty of obtaining samples has limited the scientific evidence, leaving many issues unresolved
- Eyewitness accounts are extensive and indicate possibility of some form of chemical warfare, but show methodological problems
- Medical evidence is hard to analyze because of serious health problems in the affected areas, some possibly due to toxin-infested food

Liquidity Proves Tough For Chemical Firms To Rebuild

Companies show some of usual progress in rebuilding cash assets after recession, but short-term debt has grown considerably at same time

William J. Storck, C&EN New York

Last year, the first after a rough recession, typically would have been a time for U.S. chemical companies to rebuild their liquidity (cash and relative cash coverage of liabilities). At least that was the hope of many chemical company executives and chemical industry analysts as the year began. However, through the third quarter, a C&EN survey shows that in many cases that hope was only part way to reality.

The standard dogma is that companies should build liquidity during and immediately following a recession by tightening their inventories and accounts receivable. If that can be done, drains on corporate cash should abate, and cash and marketable securities should increase. This comes about through a reduction in financing requirements and a fresh earnings gain in the initial recovery stage.

At the beginning of 1983, it seemed that chemical management had inventories under control, and that if chemical demand and earnings improved throughout the year, corporate balance sheets would come out looking much better. However, a recent survey by C&EN of chemical companies' third-quarter stockholders reports shows that there were some flies in the ointment during the first nine months of the year and that, whereas inventories did not build, other parts of the balance sheets did, much to the detriment of liquidity.

Third-quarter cash was up 25% for chemical companies

$ Millions	Cash plus marketable securities	% change from 1982[a]	Current ratio 1983	Current ratio 1982[b]	Cash ratio 1983	Cash ratio 1982[a]
CHEMICAL FIRMS	$2332.1	24.8%	1.8	1.9	0.23	0.18
American Cyanamid	347.8	8.8	2.0	2.0	0.46	0.42
Celanese	na	na	1.7	1.9	na	na
Dow Chemical	195.0	6.6	1.4	1.8	0.07	0.08
Essex Chemical	4.9	−30.0	2.3	3.1	0.16	0.32
First Mississippi	2.0	−13.0	1.5	0.7	0.04	0.02
Freeport McMoRan	0.8	−61.9	1.6	1.4	0.00	0.01
W. R. Grace	206.7	25.7	1.9	1.7	0.22	0.16
Monsanto	566.0	36.7	2.3	2.6	0.50	0.44
Morton Thiokol	210.7	b	1.4	1.1	0.59	b
Olin	124.0	60.8	2.2	1.8	0.35	0.20
Pennwalt	87.8	497.3	2.8	1.9	0.57	0.08
Petrolite	na	na	3.3	2.9	na	na
Reichhold Chemicals	5.7	−62.5	2.2	2.7	0.07	0.21
Stauffer Chemical	143.6	−3.4	2.3	2.5	0.42	0.45
Union Carbide	158.0	2.6	1.8	2.0	0.08	0.09
Williams Cos.	279.1	41.5	1.7	1.7	0.80	0.57
DIVERSIFIED FIRMS	$2341.1	47.2%	1.7	1.9	0.25	0.19
Borg-Warner	106.2	22.6	1.7	1.6	0.20	0.16
Du Pont	1495.0	49.6	1.7	1.9	0.27	0.21
Eli Lilly	495.8	63.2	1.9	1.9	0.52	0.35
Georgia-Pacific	37.0	2.8	1.5	1.7	0.04	0.05
B. F. Goodrich	19.6	−56.3	1.8	1.6	0.04	0.08
NL Industries	30.3	−42.0	2.1	2.2	0.09	0.14
Uniroyal	157.2	131.2	2.4	2.5	0.42	0.22

a 1982 figures are for fourth quarter. b 1982 figures are not available. na = not available.

Chemical corporations indeed raised their cash and marketable securities through the third quarter. Of the 16 major chemical companies surveyed by C&EN, 13 gave comparable data on cash and marketables. These 13 had a total of cash and marketable securities of $2.12 billion, a nearly 25% increase over the same companies' total at the end of 1982. Fourth-quarter 1982 figures were used for comparison because the data were more consistent and because it was the low point of the chemical recession.

By contrast, a small group of seven randomly selected diversified companies with substantial chemical interests had an average increase in cash and marketables of a little more than 47% to a total of $2.34 billion, mainly on large increases of 63% for Eli Lilly and 131% for Uniroyal.

A few of the chemical companies surveyed also had healthy increases. The outstanding one was a 497% jump for Pennwalt. Other increases included 61% for Olin, 42% for Williams Cos., and 37% for Monsanto. However, cash and marketables fell for some companies, including 63% for Reichhold Chemicals, 62% for Freeport McMoRan, 30% for Essex Chemical, and 13% for First Mississippi.

In spite of the increase in combined cash and marketables among the chemical companies, the broadest measure of corporate liquidity—the current ratio—actually decreased during the first three quarters. This ratio of current assets divided by current liabilities fell slightly in the third quarter to 1.8 for the group of 16 chemical firms from 1.9 in the fourth quarter last year.

The reason for the slight decline is that although current assets for the group increased 5.1% to $18.7 billion, current liabilities rose more than twice as much. Combined current liabilities at the 16 companies rose an average of 11% from fourth-quarter 1982 to $10.3 billion in third-quarter 1983.

The current ratio fell even more for the diversified companies. Their current assets rose 3.8% in the period to $16.2 billion, but current liabilities jumped almost 14% to $9.3 billion. That sent the current ratio down to 1.7 at the end of last year's third quarter from 1.9 at the end of fourth-quarter 1982.

Because the cash and marketable securities portion of the current assets was increasing faster than current liabilities, however, the cash ratio (cash and marketables divided by current liabilities) increased moderately by the end of the third quarter for the chemical firms and the diversifieds alike. The average cash ratio for the chemical companies increased to 0.23 at the end of the third quarter from 0.18 in fourth-quarter 1982, and the ratio for the diversifieds rose to an average of 0.25 from 0.19.

The cash ratio increase for chemical companies was helped greatly by increases for Williams Cos. to 0.80 from 0.57 and for Monsanto to 0.50, the best among the biggest companies, from 0.44.

One of the reasons that current assets did not increase very fast is that inventories seemed to go nowhere in the nine months. However, this may be good since inventories are, at best, a dubious asset, requiring cash in one form or another to finance them. Inventories for the chemical companies at the end of the third quarter of last year amounted to a total of $6.63 billion, up an average of just 0.7% from fourth-quarter 1982. For the diversified companies, inventories actually declined a slight 0.5% to a total of $6.42 billion.

The other factor in current assets, accounts receivable, reached a total of $7.69 billion for the chemical companies by the end of last year's third quarter, a 7% increase from fourth-quarter 1982. For the diversified companies, accounts receivable increased an average of 5.9% to a total of $6.67 billion.

On the liabilities side, short-term debt increased substantially in the nine months, indicating that some companies, at least, may not have their financing under control yet. These companies still had to borrow a lot of money in the first recovery year.

Short-term debt for the 16 chemical companies climbed about 37% during the nine-month period to a total of $2.17 billion. Freeport McMoRan's debt increased the most, 1693%. But the chemical group's average increase was affected significantly by Dow Chemical, whose short-term debt rose 170% to $746 million. □

Inventories were flat, but receivables, payables, and short-term debt rose in third quarter

	Inventories		%	Receivables		%	Accounts payable		%	Short-term debt		%
$ Millions	1983	1982[a]	change	1983	1982[a]	change	1983	1982[a]	change	1983	1982[a]	change
CHEMICAL FIRMS	**$6633.3**	**$6584.8**	**0.7%**	**$7692.9**	**$7190.3**	**7.0%**	**$3836.6**	**$3583.2**	**7.1%**	**$2172.7**	**$1591.2**	**36.5%**
American Cyanamid	489.1	513.5	−4.8	669.8	681.4	−1.7	559.3	572.9	−2.4	144.2	138.2	4.3
Dow Chemical	1853.0	1746.0	6.1	2356.0	2034.0	15.8	1189.0	1055.0	12.7	746.0	276.0	170.3
Essex Chemical	20.6	22.2	−7.2	43.7	30.4	43.8	11.5	9.7	18.6	12.1	5.3	128.3
First Mississippi	23.2	23.6	−1.7	38.2	29.4	29.9	24.1	7.0	244.3	7.8	53.9	−85.5
Freeport-McMoRan	77.6	90.6	−14.3	107.1	124.2	−13.8	112.0	149.7	−25.2	52.0	2.9	1693.1
W. R. Grace	931.7	878.0	6.1	635.7	621.4	2.3	471.3	473.3	−0.4	167.9	177.9	−5.6
Monsanto	819.0	824.0	−0.6	1242.0	1216.0	2.1	523.0	379.0	38.0	193.0	131.0	47.3
Olin	254.4	265.3	−4.1	346.6	274.8	26.1	99.1	136.2	−27.2	52.5	87.5	−40.0
Pennwalt	137.6	141.0	−2.4	177.5	147.4	20.4	50.5	49.9	1.2	14.2	60.2	−76.4
Reichhold Chemicals	51.5	61.5	−16.3	124.8	101.5	23.0	67.9	59.8	13.5	13.6	9.9	37.4
Stauffer Chemical	316.6	279.1	13.4	269.1	364.2	−26.1	115.4	99.4	16.1	114.5	113.6	0.8
Union Carbide	1659.0	1740.0	−4.7	1558.0	1420.0	9.7	440.0	415.0	6.0	601.0	487.0	23.4
Williams Cos.	184.8	246.8	−25.1	124.4	145.6	−14.6	173.5	176.3	−1.6	53.9	47.8	12.8
DIVERSIFIED FIRMS	**$6424.7**	**$6454.0**	**−0.5%**	**$6668.3**	**$6298.7**	**5.9%**	**$4186.9**	**$4579.3**	**−8.6%**	**$1526.6**	**$ 864.2**	**76.6%**
Borg-Warner	290.8	300.9	−3.4	426.1	429.6	−0.8	244.0	259.9	−6.1	42.2	62.1	−32.0
Du Pont	3725.0	3690.0	0.9	3787.0	3659.0	3.5	2175.0	2636.0	−17.5	912.0	319.0	−185.9
Eli Lilly	650.3	658.3	−1.2	511.5	555.7	−8.0	638.4	628.0	1.7	315.8	245.6	28.6
Georgia-Pacific	719.0	699.0	2.9	695.0	572.0	21.5	403.0	340.0	18.5	216.0	195.0	10.8
B. F. Goodrich	413.1	400.1	3.2	549.0	371.1	48.1	500.5	444.8	12.5	11.6	17.1	−32.2
NL Industries	293.9	359.6	−18.3	336.4	391.4	−14.1	226.0	270.6	−16.5	29.0	25.4	14.2
Uniroyal	332.6	346.1	−3.9	362.6	319.9	13.3	na	na	na	na	na	na

[a] 1982 figures are for fourth quarter. na = not available.

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Chemical firms plan modest R&D funding increase this year
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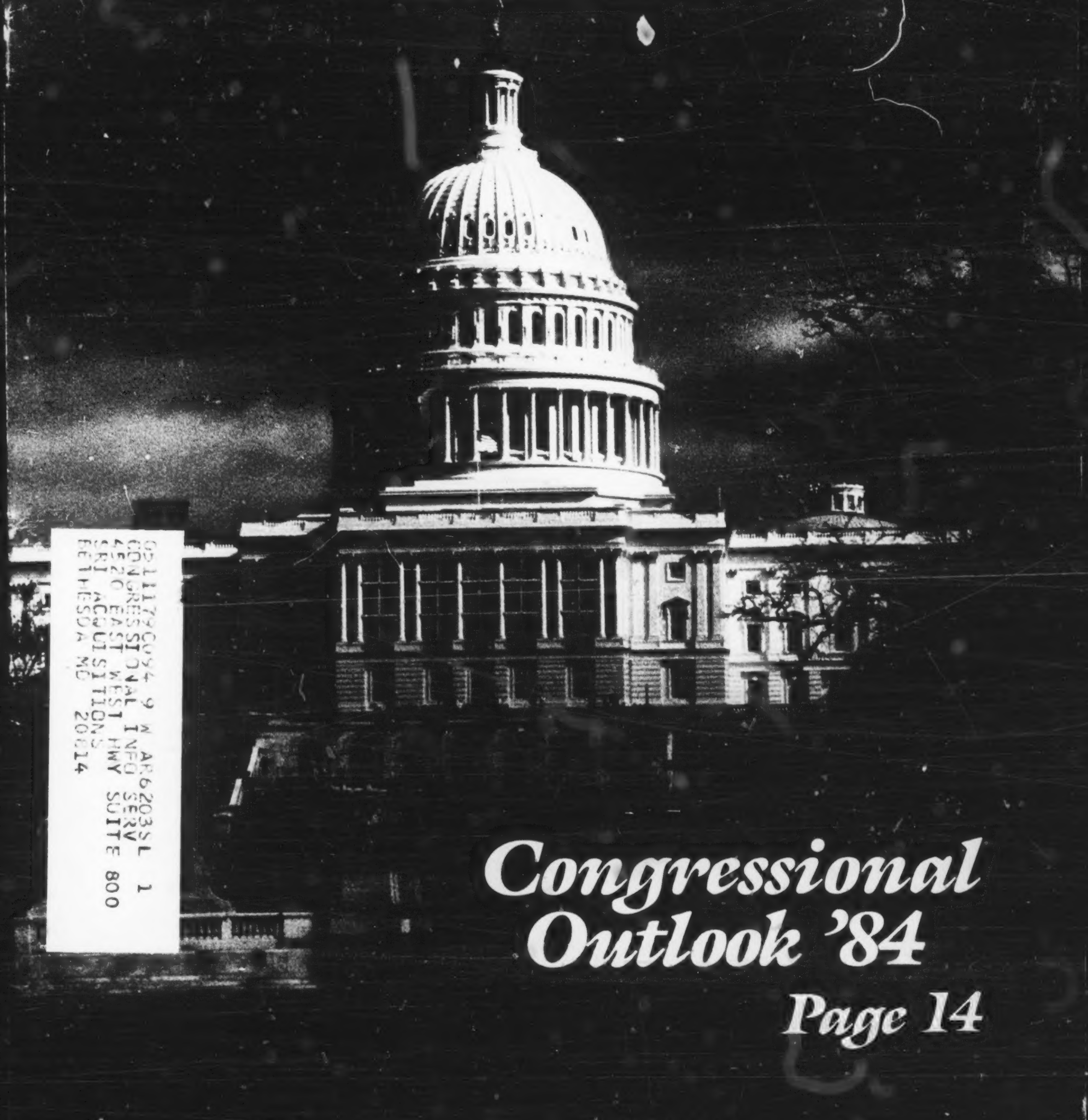

Congressional Outlook '84

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- **Texaco's acquisition of Getty Oil would be largest buyout in U.S. history.** Page 6
- **Reports of proton decay, from five research teams, are not considered definitive.** Page 7
- **NASA asks for proposals defining orbiting space tug to reposition satellites.** Page 7
- **Occidental Chemical agrees to clean up hazardous waste site at Niagara Falls, maintain safe drinking water supply.** Page 8
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U.S. chemical spending for R&D will increase in 1984 but only about 7%, barely above the inflation rate; many chemical company executives have change-of-control contracts. **Page 25**

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Canadian government economic policies must be more flexible, responsive to the marketplace, chemical exec advises. **Page 28**

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Number of people receiving doctorates in physical sciences and engineering is increasing after declines from the 1970s. **Page 58**

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Second session of the 98th Congress must tackle budget, energy, environment, patents, in election year. Page 14

Chemical Firms' R&D Spending Will Rise Only Modestly in 1984

Planned boost in R&D funding by U.S. basic chemical firms of about 7% marks second consecutive year of small increases

David Webber, C&EN New York

Despite the strong recovery of earnings in the third quarter of 1983 and general expectation that fourth-quarter results, soon to be revealed, will look even healthier, chemical companies are planning only modest increases in their research and development budgets in 1984. A dozen large basic chemical firms surveyed by C&EN anticipate spending an average of just 7% more this year than last.

The relatively small boost not only provides a fairly narrow margin over expected higher costs—industrial R&D inflation will hit 5.3% this year, according to Battelle Columbus Laboratories—it also marks the second consecutive year in which R&D budgets will rise by a smaller percentage than they did the year before. Even aggressive research spenders like American Cyanamid, Dow Chemical, and Du Pont are expanding their budgets less than in 1983.

In consequence, although the technical professional unemployment rate as measured by the Bureau of Labor Statistics has fallen sharply since the summer, professional R&D staff size at chemical companies will grow only slightly—from 23,900 in 1983, according to the National Science Foundation, to some 24,300 this year. That level, however, still would be less than the 24,700 full-time R&D scientists and engineers (on an equivalent basis) working in the industrial chemical industry at the beginning of 1982.

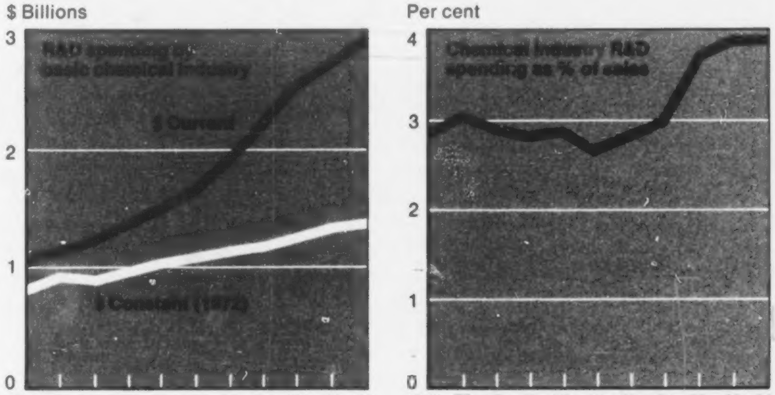
Companies will just not be spending enough money, on an inflation-adjusted basis, to hire many more R&D personnel. Based on Battelle Columbus Labs' cost of research index for the industry sector, constant-dollar (1972) spending for the companies surveyed by C&EN will rise to an estimated $1.32 billion in 1984 from $1.31 billion in 1983, an increase of just 1%.

The generally cautious approach to R&D spending shows even more clearly in the failure of more than half of the 12 companies whose budgets had been prepared by press time to plan budget increases higher than this year's projected research inflation rate. Only a handful of companies are responsible for the average boost. Indeed, if Du Pont figures (excluding Conoco), which lead the industry at a massive $945 million, were deleted from both 1983 and 1984 totals, overall industry R&D spending would be moving up at barely more than the inflation rate this year.

All this contrasts sharply with the heady growth in research budgets that characterized much of the half-decade before the 1983 decline. Double-digit increases, peaking at 16% in 1980, were the norm. And these big budget hikes exceeded the soaring inflation of the time as well. Between 1978 and 1982, constant-dollar spending on chemical R&D rose from $1.03 billion to $1.29 billion, a gain of more than 25%.

During the same period, chemical company R&D spending as a percentage of sales rose sharply, a seeming indication of growing chemical industry emphasis on research. The steady growth, from 2.7% in 1979 to 3.9% last year, is actually artificially high, because sales were dropping during much of the time span during which R&D spending was ascending. The most drastic gain can be seen in 1982, a recession year, when the share of

R&D budget increases will exceed inflation this year... ...but will remain unchanged as a per cent of sales



Sources: C&EN surveys, Battelle Columbus Laboratories

R&D spending gains will slow for second year in a row in 1984

$ Millions	Planned 1984	Actual 1983	Planned 1983	1982	1981	1980	1979	1978	Change from previous year 1984	Change from previous year 1983	R&D spending as % of sales 1983	R&D spending as % of sales 1982
Air Products	$ 42	$ 40	$ 40	$ 37	$ 32	$ 30	$ 24	$ 23	5%	8%	2.4%	2.3%
American Cyanamid	235	210	200	180	164	142	124	108	12	17	6.0	5.2
Celanese	na	na	100	100	104	94	92	83	na	na	na	3.3
Dow Chemical	508	485	480	455	404	314	269	232	5	7	4.5	4.3
Du Pont[a]	945	875	880	775	647	591	509	461	8	13	5.7	5.4
Ethyl	39	39	39	38	37	34	29	25	0	3	2.2	2.4
W. R. Grace	82	69	71	59	55	45	42	37	19	17	1.1	1.0
Hercules	66	66	68	67	61	53	47	40	0	−1	2.5	2.7
Lubrizol	38	36	36	36	33	28	23	21	6	0	4.4	4.5
Monsanto	na	na	284	264	221	204	161	136	na	na	na	4.2
Olin	55	50	48	45	39	31	26	25	10	11	2.6	2.5
PPG Industries	125	125	125	127	119	103	83	70	0	−2	3.4	3.9
Rohm & Haas	na	na	94	91	77	67	54	49	na	na	na	5.0
Stauffer Chemical[b]	66	63	64	57	49	44	35	32	5	11	4.7	3.6
Union Carbide	250	238	238	237	201	166	161	156	5	0	2.7	2.6
TOTAL	**$2451**[c]	**$2296**[c]	**$2767**	**$2568**	**$2243**	**$1946**	**$1679**	**$1498**			**3.2%**	**3.7%**
ANNUAL CHANGE	**7%**	**9%**	**8%**	**14%**	**15%**	**16%**	**12%**	**12%**				

a All figures exclude Conoco. b All figures restated for fiscal year ending Sept. 30. c For 12 reporting companies only. na = not available. **Note:** R&D expenditures from 1978 to present restated to include R&D spending as part of marketing function.

sales devoted to R&D budgets shot up to 3.8% from 3.0% in 1981.

This year, chemical research spending and sales are forecast to rise at about the same 7% pace. As a result, the ratio of research dollars to sales will remain at 3.9%.

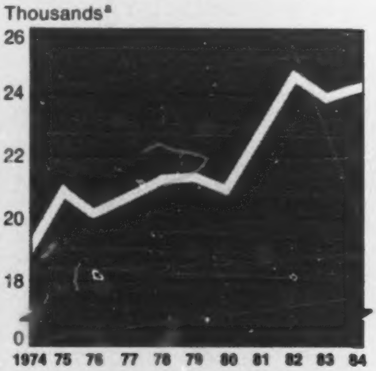
As last year, the company proposing the biggest R&D spending increase is W. R. Grace, with a 19% rise planned after 1983's 17% hike. But Grace, at $82 million, will remain just a middling spender. The major boosts will come from American Cyanamid, boosting spending 12% to $235 million, a $25 million increase from actual 1983 spending. Du Pont definitely is showing its teeth with an 8% increase in 1984 after a 13% hike last year. In current money, Du Pont R&D spending (exclusive of Conoco) will rise $70 million.

The only other chemical firms that have planned to increase their R&D budgets more than inflation are relatively small spenders: Olin, with a 10% increase to $55 million, and Lubrizol, after no increase in 1983, with a 6% boost to $38 million.

Dow Chemical, the second most prolific R&D spender, is raising its budget just 5% to $508 million this year, up from $485 million in 1983. An increase of the same proportion is planned by Union Carbide, whose 1984 R&D expenditures are expected to total some $250 million, up from $238 million last year. Three major firms—Celanese, Monsanto, and Rohm & Haas—did not have their 1984 R&D budgets prepared at press time.

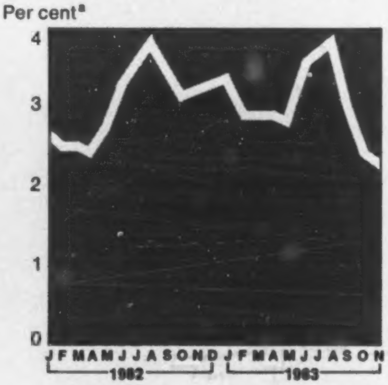
At a point at which companies are nearly as cautious about commitments to expenditure as they were last year at this time, it is not surprising that it is those firms which traditionally have spent heavily on research which are leading the way. American Cyanamid, for instance, had an R&D spending-to-sales ratio of 6.0% last year. At Du Pont, spending on R&D accounted for 5.7% of sales. And among the other companies surveyed, it is mostly those which spend at least 4.0% of their sales dollars on research which are increasing R&D budgets by about the inflation rate. ◻

Professional R&D staffs begin to swell again . . .



a Full-time equivalent R&D scientists and engineers in basic chemical industry at beginning of year. **Sources:** National Science Foundation, C&EN surveys

. . . and technical professional unemployment falls sharply



a Unemployment rate for professional specialty employees, including engineers, mathematical and computer scientists, natural scientists, health diagnosing occupations, health assessment and treating occupations, teachers, lawyers, and judges. Not seasonally adjusted. **Source:** Bureau of Labor Statistics

Increasing Energy Productivity Could Ease Greenhouse Effect

MIT/Stanford study tests effects of energy options on future buildup of atmospheric carbon dioxide using new, highly disaggregated model

On the basis of current understanding of the effect of carbon dioxide on climate and trends in global energy use, a significant CO_2 warming in the next century probably cannot be avoided. But early action will help to minimize later difficulties, and the most important and effective options relate to an increase in energy productivity worldwide.

That's the basic conclusion of a new study titled, "Global Energy Futures and CO_2-Induced Climate Change." Prepared for the National Science Foundation, the study was carried out by nuclear engineering professor David J. Rose of Massachusetts Institute of Technology, working with Marvin M. Miller of the MIT department of nuclear engineering and the energy laboratory and Carson Agnew of the engineering-economic systems department of Stanford University.

The new study follows closely a major study by the National Research Council and another by the Environmental Protection Agency (C&EN, Oct. 31, 1983, page 22). However, greenhouse-effect warming of Earth is a problem of such scientific, technological, and social complexity and dimension that no one study, or even series of studies, can exhaust the possible variations on the theme. The new study, which uses a different model than others for its calculations, thus adds to the continuing dialogue on the topic by taking a slightly different viewpoint and focusing on energy options relevant to ameliorating the buildup of CO_2 in the atmosphere in future years.

Whether a warming will occur isn't a central issue in the MIT/Stanford study. It accepts as given that increasing CO_2 will raise the mean global temperature and that such temperature rises due to CO_2,

MIT develops 11 scenarios that lead to different energy values in the year 2025

Scenario	Gross domestic product	Energy	Energy per GDP
Base case:[a] Availability of large quantities of inexpensive fossil fuels, particularly coal; an energy end-use efficiency increase of 1% per year in the industrial sector of Organization for Economic Cooperation & Development countries; no increases in end-use efficiency in OECD transportation and residential/commercial sectors or any sectors in non-OECD countries	1.00	1.00	1.00
Case A: Higher oil and gas prices; reduced biomass resources; higher nuclear costs	0.99	0.77	0.71
Case B: Reduced reserves and higher prices for coal	0.99	0.71	0.72
Case C: Combination of cases A and B (higher fossil fuel prices; smaller coal reserves; higher nuclear costs; reduced biomass resources)	0.97	0.59	0.61
Case D: Increased efficiencies; higher synfuel costs; optimistic view of development of photovoltaic technology; coal same as base case (large reserves at inexpensive prices)	1.00	0.78	0.78
Case E: Combination of all changes from previous cases except lower nuclear costs (as in base case)	0.98	0.65	0.66
Case F: Similar to case C but with solar costs greater than those of case D (about same as base case)	0.98	0.59	0.60
Case H: Case E but with no nuclear installations after year 2000	0.97	0.59	0.61
Case J: Case E but with higher unconventional oil price; cutoff in oil from Middle East in 2000; increased end-use energy efficiencies everywhere, in all sectors	0.98	0.52	0.53
Case K: Base case but with increased end-use efficiencies though less than cases A through J; higher nuclear costs; Middle East oil supply cutoff at 2000	0.98	0.71	0.72
Case L: Case E but with large decrease in unconventional resources; slight decrease in coal prices, increased end-use efficiencies	0.98	0.55	0.56
Case M: High end-use efficiencies; small coal reserves; high coal prices; small biomass resource; no unconventional oil; low solar prices	0.98	0.52	0.53

[a] Institute for Energy Analysis.

coupled with contributions from other greenhouse gases such as nitrogen oxides and chlorofluoromethanes, are much larger than anything in recorded history. Noting that well-recognized uncertainties exist in both timing and consequences of climate changes, the study finds that stringent measures to restrict use of fossil fuels now are both unjustified and infeasible.

However, there is potential for severe impacts, the possibility that such impacts will have a negative synergism with other environmental stresses occurring at the same time, and inertia in the energy supply and demand system. Hence, the study maintains, it makes sense to develop new strategies for reducing future fossil fuel carbon emissions, rather than relying solely on research to narrow uncertainties and/or ameliorative measures, such as building dikes and developing new strains of "greenhouse-resistant" crops.

Thus, the study concludes that the rate of increase of atmospheric CO_2 attributed to fossil fuel consumption can be reduced significantly through adoption of realistic energy strategies that the study terms relatively "CO_2-benign." It uses the term CO_2-benign to mean an atmospheric CO_2 increase from the present 340 ppm by volume to about 420 ppm by volume by the year 2050. Such an increase corresponds to a CO_2 doubling time of several centuries.

"While technical and other limits bound the range and composition of future global energy use," the study says, "the bounds appear to be fairly wide, with a spread of a factor of several in annual carbon emissions by the middle of the next century."

The most important and effective options, according to the study, relate to increasing energy productivity on a worldwide scale—an activity, it points out, that is beneficial quite apart from its impact on CO_2 and climate, and that can lead to a halving of global energy requirements per unit of production or service in less than 50 years. It will be impossible to develop global consensus for any one simple set of energy options, the study notes, because of different stages of industrialization, different available resources, different perceptions of climatological or economic winning or losing, and the like. However, based on recent attention to other international environmental problems such as acid rain, the study concludes that the time seems propitious for extending the global debate on the CO_2-climate issue.

Models play a central role in studies of the CO_2-climate issue. For example, the recent NRC study involved a model developed by economist William D. Nordhaus of Yale University along with Gary W. Yohe of Wesleyan University. That model went beyond earlier efforts that involved extrapolative techniques. Nordhaus and Yohe used what they call probabilistic scenario analysis to arrive at a projection that is not only a best guess but also a set of alternative trajectories and associated probabilities.

The MIT/Stanford resesarchers make note of the Nordhaus-Yohe model, as well as one by Gregory Hamm of Stanford's engineering-economic systems department. For their work, however, they chose a model developed by James Edmonds and John Reilly of the Institute for Energy Analysis, a component of Oak Ridge Associated Universities.

In comparing the models, the current study points out the importance of keeping in mind that the intent of the modelers is different. Nordhaus and Yohe, for instance, are interested mainly in determining the effect of current uncertainties in various energy-economic-carbon cycle parameters on the range of possible future paths for energy use and CO_2 emissions. Hamm's model, the study notes, seeks optimum futures in terms of an objective function that includes both discounted consumption and the effects of resource depletion, as well as a production function that accounts for CO_2 feedbacks to the economic sector. In both cases, a highly aggregated approach is used in an attempt to gain insight into the relative importance of uncertainties in the parameters that drive the energy-economic system.

The Edmonds and Reilly model, on the other hand, is intended as an analytic tool for exploring how alternative energy-CO_2 futures depend on a much more detailed specification of the energy-economic system. As such, the model is more difficult to use but gives the user more degrees of freedom to explore.

Thus, in comparison with the other models, the Edmonds and Reilly model is highly disaggregated. In principle, the MIT/Stanford study notes, it is useful for determining how future energy paths and CO_2 emissions depend on the relationships among the economy, energy supply and demand, and technological change. The study points out that the price the user pays for this flexibility is not an excessive amount of computation but the need to specify more than 60 categories of inputs, many of which can be further disaggregated by region, fuel type, and year.

Whereas the Nordhaus-Yohe and Hamm models contain no geographical disaggregation, for example, the Edmonds and Reilly model includes nine global regions, with end use in regions of the Organization for Economic Cooperation & Development divided into industrial, transport, and commercial/residential sectors. Similarly, whereas the other two models each contain one fossil and one nonfossil for energy supply types, the Edmonds and Reilly model has provision among types of energy supply for nine primary types, four secondary, and for solids, liquids, gases, and electricity.

Using an Institute for Energy Analysis scenario as a base case, the MIT/Stanford researchers developed 11 scenarios for analysis using the model. All assume increased end-use efficiencies, compared with the base case, and, except for one, have higher synfuel costs. They also explored the impact of both evolutionary and abrupt changes in energy supply conditions.

Several relatively CO_2-benign scenarios, the researchers note, are not low-energy in a Draconian sense. They would, however, require global awareness and collaboration, starting very soon. "While perhaps at the lower limit of possible realities," the researchers say, "these scenarios do not appear to us impossible." □

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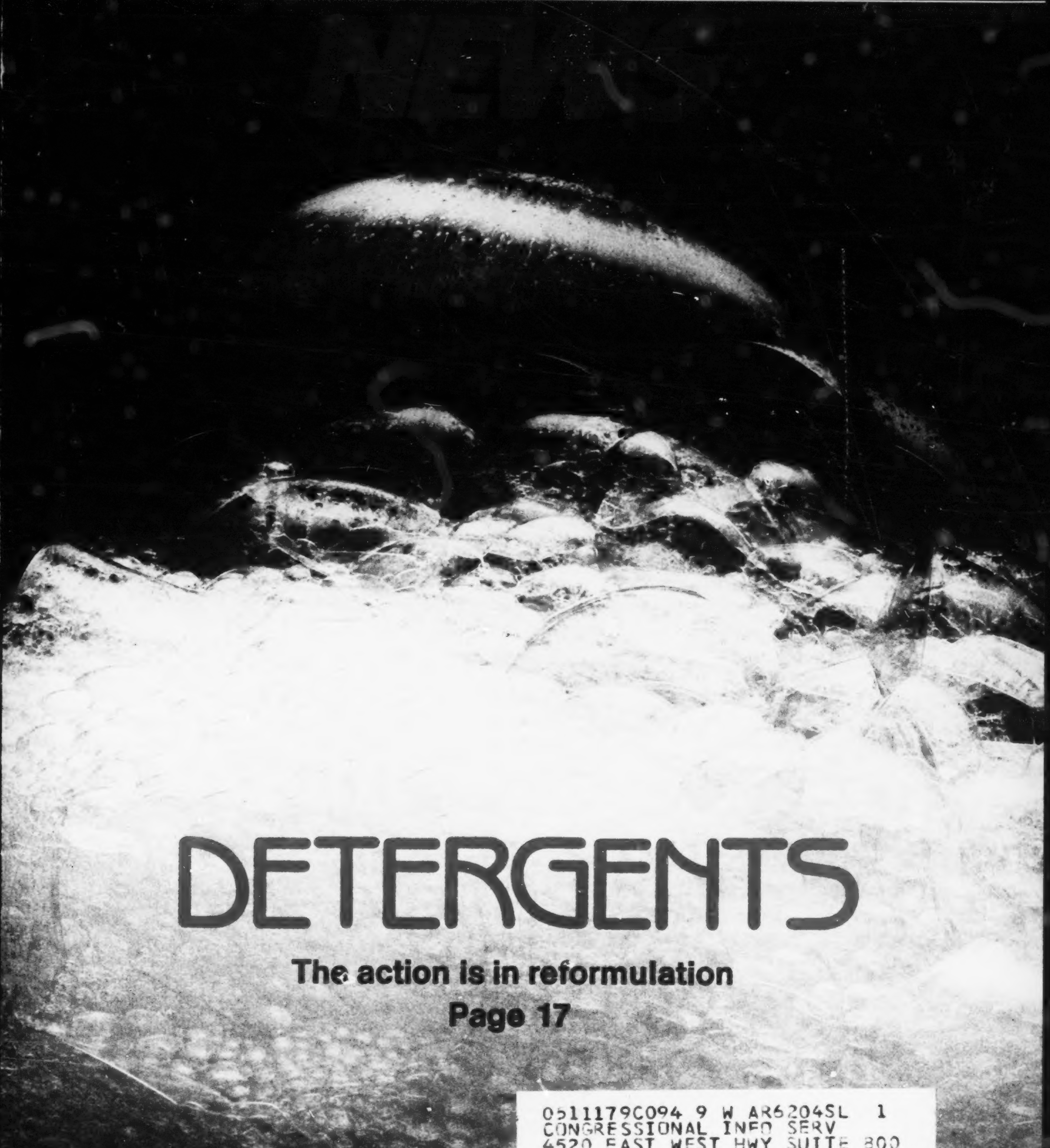

DETERGENTS

The action is in reformulation

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CHEMICAL & ENGINEERING
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JANUARY 23, 1984

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- **Monsanto's acquisition of Belgian firm Continental Pharma would plump up U.S. firm's new health care division.** **Page 6**
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Detergent Report

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U.S. CHEMICAL TRADE: EEC threatens higher tariffs, quotas

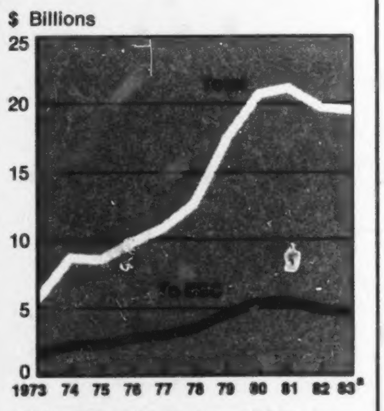
Chemicals once again have become a pawn in a trade battle between the U.S. and the European Economic Community.

In retaliation against restrictions that President Reagan imposed last July on specialty steel imports from EEC countries, the community's governing commission has threatened to impose higher tariffs on some U.S. chemical exports and set quotas on others. The EEC action will become effective March 1, unless officials in the Office of the U.S. Trade Representative (USTR) can come up with a satisfactory package of trade concessions to compensate EEC for the curbs against its specialty steel shipments.

The higher tariffs will hit U.S. exports of methanol and vinyl acetate to EEC countries. Quotas are targeted against styrene and certain grades of polyethylene sheet.

The duties on both methanol and vinyl acetate will increase almost 50%. For methanol, the tariff will rise from 13.5% to 19.9% by adding a 6.4% surcharge. The vinyl acetate duty will jump from 13.2% to 19.6%. These rates of duty, however, will be effective only in 1984. As a result of agreements reached earlier during the Tokyo round of multilateral trade negotiations, EEC and the U.S. are in the middle of an eight-year staged reduction in chemical tariffs. Accordingly, both EEC's statutory duty and the surcharge on U.S. methanol and vinyl acetate shipments will decline through 1987.

One fourth of U.S. chemical exports go to EEC



a C&EN estimates. Source: Census Bureau

EEC is an important market for both products. In 1982, U.S. companies shipped $32.3 million worth of methanol to EEC countries, 36.2% of total methanol exports. U.S. vinyl acetate exports to EEC countries amounted to $32.7 million, or 21.5% of the total.

Rather than increase tariffs, EEC will slap quotas on U.S. shipments of styrene and certain grades of polyethylene sheet. The styrene quota is 25.6 million ECU (European currency unit). Early reports mistakenly listed the styrene quota at $25.6 million. But the exchange rate between the ECU and the dollar is constantly changing. Last year's average was about 90 cents per ECU. The current rate is about 81 cents per ECU.

An EEC spokesman says that the quota was listed in terms of the ECU because of the uncertain exchange rate. It would have been simpler, however, if the quota had been set by volume, rather than by value, she adds.

The quota on polyethylene sheet varies, depending upon thickness and density. The total value of the quota on three grades of sheet, however, amounts to 13.6 million ECU.

Before the EEC product list became official, rumor indicated that quotas would be imposed on low-density and high-density polyethylene resin (a much larger category) rather than on polyethylene sheet. Had this been true, the outcry from the U.S. chemical industry would have been far louder than it has been.

EEC retaliation hits U.S. chemical exports two ways

Higher duties on methanol and vinyl acetate . . .

	Statutory duty, %	New surcharge, %	Resulting new duty, %
Methanol			
1984	13.5%	6.4%	19.9%
1985	13.4	5.1	18.5
1986	13.2	3.9	17.1
1987	13.0	2.7	15.7
Vinyl acetate			
1984	13.2	6.4	19.6
1985	12.6	5.1	17.7
1986	12.1	3.9	16.0
1987	11.5	2.7	14.2

. . . and quotas on styrene and polyethylene sheet

	Quota (millions of ECUᵃ)
Styrene	25.6
Polyethylene sheet	13.6
0.1 mm or less, density less than 0.94	9.1
0.1 mm or less, density 0.94 or more	2.0
More than 0.1 mm	2.5

Note: Effective March 1, 1984. a European currency units. Currently, 1 ECU = about 81 cents; 1983 average was 1 ECU = about 90 cents. Source: European Economic Community

Considering past heated trade battles between the U.S. and EEC over chemicals, the reaction of U.S. chemical industry trade experts has been quite subdued. Most of them think that the EEC retaliation against chemicals is unfair. They feel that the U.S. chemical industry is paying the price for the steel industry's protection.

However, other than relay those feelings to the USTR office, there is very little that they can do about it. The Chemical Manufacturers Association is contacting chemical companies to determine the full impact of EEC's tariff and quota moves. It will pass these data along to USTR, which, hopefully, can put them to good use in continuing negotiations with EEC trade officials.

There is still the possibility that the U.S. and EEC can reach agreement on a trade compensation deal before EEC's retaliatory moves become effective on March 1. Presumably, the two sides were close to an agreement before the tariff and quota action was announced. And some chemical trade experts see this action as an EEC attempt to prod U.S. officials into offering a satisfactory package of compensation.

Others believe that it is all but impossible for the two sides to reach agreement before the March 1 deadline. And they speculate that, if the U.S. decides to counterretaliate, a full-scale trade war between the two blocs could erupt.

It seems unlikely that negotiators on either side will allow this to happen. The present disagreement involves only about $160 million in trade. That includes not only the proposed EEC tariffs and quotas on chemicals, but similar restrictions on some sporting goods and burglar alarms.

Compared to this small value of U.S. steel restrictions and EEC retaliatory steps, total U.S.-EEC trade is huge. U.S. exports to EEC countries were $48 billion in 1982. Imports were $43 billion. □

Monsanto to acquire Belgian drug firm

Monsanto's fledgling health care business may have its first commercial products if a deal goes through for it to acquire Continental Pharma, a Belgian pharmaceutical company.

Continental Pharma is a privately owned company with sales in 1983 of about $40 million. It employs about 570 people at offices, three manufacturing plants, and a research center in Belgium. It produces ethical pharmaceuticals, which it markets primarily in Belgium and through licenses in other parts of the world. Continental Pharma's largest product, which it invented and markets, is Suloctidil, used to enhance peripheral and cerebral blood circulation. It is being studied in the U.S. for treatment of senility.

Monsanto, which expects to complete the acquisition by May, set up its health care division early last year, but so far has had no sales. The division was established to develop market strategy and has functioned essentially as a venture capital operation to provide funds to such biotechnology companies as Biogen and Collogen and to fund Monsanto's research grants to universities such as Washington University and Oxford.

Richard J. Mahoney, Monsanto's president and chief executive officer, says the planned acquisition is "an important step in plans to develop growth opportunities for Monsanto in health care products."

The Belgian company's research base would be expected to accelerate Monsanto's own R&D efforts in pharmaceuticals. □

Earl L. Muetterties dies at 56

Earl L. Muetterties

Earl L. Muetterties, professor of chemistry at the University of California, Berkeley, and senior scientist at Lawrence Berkeley Laboratory, died Jan. 12 of cancer at his home in Oakland, Calif. He was 56.

A major figure in the world of inorganic chemistry, Muetterties made significant contributions to the fields of nuclear magnetic resonance, boron chemistry, organometallic chemistry, and surface science. He wrote more than 300 papers for scientific journals and was the inventor or coinventor responsible for about 100 U.S. and foreign patents.

"Many in research are productive in the sense that they add to the descriptive matter of the field of chemistry; and Muetterties has to his credit a large number of papers, carefully describing experimental work carefully done, which have expanded our knowledge of chemical systems," a colleague says. "Much rarer are the individuals who make contributions so basic and so significant that they transform a research area. Muetterties has done this in two major areas of inorganic chemistry: boron compounds and the stereochemistry of nonrigid species."

For the past several years, Muetterties' work has examined homogeneous catalysis by transition metal complexes."Though many have referred to the opportunities in the field, Muetterties is the leader in changing potential to reality," the colleague says.

Muetterties began his scientific career at Du Pont's central research department in 1952 and was associate director of research there from 1965 to 1973. He was a professor of chemistry at Cornell University from 1973 to 1978 when he joined the faculty at Berkeley. He is survived by his wife, JoAnn, and six children. □

Reproductive hazards in workplace probed

A comprehensive examination of the issue of reproductive hazards in the workplace is being undertaken by the Office of Technology Assessment. The project, formally approved by OTA's board last fall, got under way last week with the first meeting of the project's advisory panel.

Reinforced Plastics Recovery Seen for 1984

After pulling a surprising upturn out of what started for the economy as a dismal 1983, reinforced plastics producers are saying that 1984 will be even better. In fact, they say, demand for reinforced plastics in 1984 will exceed the glory years of 1978 and 1979 when demand for reinforced plastics hit its all-time peak.

At this time last year producers were saying that demand for reinforced plastics would rise about 8.4% in 1983 from 1982 levels. They got this and more, as shipments rose almost 26% from 1982. Now they are saying that shipments in 1984 will rise a little more than 12%. That would put shipments of reinforced plastics at 2.16 billion lb, compared with 1.92 billion lb in 1983 and 1.53 billion in 1982. More important, it would finally push demand for reinforced plastics above the all-time high levels of 2.06 billion lb and 2.01 billion lb in 1979 and 1978, respectively, the last good years for reinforced plastics.

For the past five years, use of reinforced plastics, in effect, has not grown. The average annual increase between 1979 and 1984 is forecast at just 0.9%. And there have been actual declines in four markets—land transportation, marine, electrical, and appliances.

Between 1974 and 1984, reinforced plastics use will have grown at an average annual rate of 4.9%. Even here, however, demand in two of the end markets—marine and aircraft—will have declined a slight 0.3% per year from a decade ago.

These forecasts were reported last week to the annual meeting of the Reinforced Plastics/Composites Institute of the Society of the Plastics Industry in Houston. They are part of the yearly survey of producers and others in the industry prepared by Laura Morrison of the New York City-based public relations firm of Morrison/Gottlieb.

The leading gainer among the major reinforced plastics markets in 1983 was consumer goods, where demand increased more than 52% from 1982 to 128 million lb. Demand for reinforced plastics in consumer goods this year is expected to be up another 12% to 143 million lb.

Related to consumer goods, appliances were the second largest market in terms of growth last year. Here demand for reinforced plastics increased about 29% to 106 million lb. For 1984, demand for reinforced plastics in appliances is expected to climb another 16% to 123 million lb.

Demand for reinforced plastics in construction last year increased 28% from 1982 to reach 400 million lb. However, producers see this growth rate slowing considerably this year as they forecast demand in construction end markets to grow only 5.5% to 422 million lb.

Land transportation, the largest market for reinforced plastics, grew almost 28% to 458 million lb, thanks in no small part to the good automobile year enjoyed by Detroit in 1983. Producers expect that 1984 growth will be at a slower but still very good rate of nearly 18%, with demand topping 500 million lb for the first time since 1979, finally coming in at about 540 million lb.

The survey shows that of reinforced plastics shipped last year, 15%, or 299 million lb, were thermoplastics. This is forecast to increase about 9% this year to 326 million lb. However, it will slow slightly as a percentage of total product shipped, still accounting for about 15% in 1984.

Four markets accounted for most of the thermoplastic demand last year. About 155 million lb went to land transportation, 55 million to appliances, 49 million to electrical uses, and 16.5 million to consumer goods. These totaled about 276 million lb, or 92% of total reinforced thermoplastics. □

Reinforced plastics demand forecast to grow 12% in 1984 to beat previous highs

								% change		Average annual change	
Millions of lb	1984[a]	1983[a]	1982	1981	1980	1979	1974	1983–84[a]	1982–83[a]	1979–84[a]	1974–84[a]
Transportation, land	540	458	359	445	416	550	293	17.9%	27.6%	−0.4%	6.3%
Marine	309	276	230	290	275	385	320	12.0	20.0	−4.3	−0.3
Construction	422	400	312	309	287	335	198	5.5	28.2	4.7	7.9
Anticorrosion	320	288	235	275	252	238	174	11.1	22.6	6.1	6.3
Electrical	189	170	140	178	162	190	94	11.2	21.4	−0.1	7.2
Appliance	123	106	82	112	104	130	82	16.0	29.3	−1.1	4.1
Consumer goods	143	128	84	110	103	126	75	11.7	52.4	2.6	6.7
Aircraft	29	25	22	28	25	23	30	16.0	13.6	4.7	−0.3
Other	80	72	64	74	70	79	75	11.1	12.5	0.3	0.6
TOTAL	2155	1923	1528	1821	1694	2056	1341	12.1%	25.9%	0.9%	4.9%

a Estimate. Source: SPI Reinforced Plastics/Composites Institute

Future for metal-coated plastics is bright

U.S. consumption of metal-plated and metal-coated plastics will double during this decade to 190 million lb in 1990 from 1980's figure of 95 million lb, according to a study by consultants Margolis Marketing & Research of New York City.

Although automotive uses still will lead in use of these materials, electrical and electronic devices will show phenomenal growth, rising to almost a quarter of the market at the end of the decade. Company president James Margolis ascribes strength in electrical and electronic applications to Federal Communications Commission requirements for shielding of devices against electromagnetic and radiofrequency interference (EMI and RFI).

Whereas electroless plating and electroplating will remain the dominant processes, Margolis predicts that newer technologies will show larger increases, to be used for more than 25% of metal-coated plastics by 1990. He justifies this forecast by citing improvements in equipment, materials, and methods, as well as continuing regulatory strictures against effluents from traditional plating.

Also, ABS (acrylonitrile-butadiene-styrene) resins will continue to be the dominant substrates, but polyphenylene oxide-polystyrene alloys promise greatest increases during the period. Margolis says that new grades of such resins together with recent development of ultraviolet-cured top and base coatings will fuel the strong advance in these materials. Also, the presently minute markets of such other engineering resins as polyphenylene sulfide and polyethersulfone will show important growth for applications that combine reflectivity with high use temperatures, strength, flame retardance, and electric field resistance.

Growth in metal-plated and metal-coated plastics for automotive uses will increase 4% yearly to 65 million lb in 1990 from 44 million lb in 1980, Margolis says. Although the automotive segment is the slowest-growing market, this amount will be 35% of total U.S. consumption of these materials. By contrast, EMI shielding needs will trigger an increase from 4 million lb in 1980 to 23 million lb in 1985 and 45 million lb in 1990, for an overall average annual growth rate of 27%.

Zinc arc spray is the technique currently most in use for EMI, though Margolis expects electroless plating to be favored in the immediate future. This is because there is a large amount of plating capacity available, and performance of plated plastics is familiar to those in the industry. Arc spray uses an electric arc between two wires to melt the metal, which is sprayed onto the substrate by a current of air. Margolis says that changes are needed in vacuum metallizing equipment before that technique can find much use in EMI, but these improvements are on the way. Effective shield coating by this method requires a three-layer, chromium-copper-chromium treatment.

Other metal coating processes that will grow in importance this decade are sputter coating and hot stamping, Margolis says. In sputter coating, a beam of cations dislodges metal atoms from a negatively charged target, and these metal atoms coat the substrate. Margolis is especially optimistic about a variation in which a magnetic field focuses metal atoms more efficiently onto the substrate. In hot stamping, heat causes attachment of adhesive-coated metal foil to the substrate, followed by peeling away of a polyester film carrier layer. Hot stamping is favored for high-gloss and/or textured decorative metal coating and for solvent, detergent, or abrasion resistance. ☐

U.S. use of metal-plated and coated plastics will grow at 7% per year in the 1980s . . .

						Annual growth, %	
Millions of lb	**1970**	**1975**	**1980**	**1985**	**1990**	**1980–85**	**1985–90**
ABS[a]	19	43	53	81	92	8.8%	2.6%
Polypropylene	6	7	10	12	17	3.7	7.2
Polyphenylene oxide	2	4	6	15	25	20.0	10.8
Polyester[b]	10	12	14	17	20	4.0	3.3
Polyvinyl chloride[b]	0	4	4	5	6	4.6	3.7
Other[c]	3	5	8	12	30	4.1	20.1
TOTAL	**40**	**75**	**90**	**142**	**190**	**8.4%**	**6.0%**

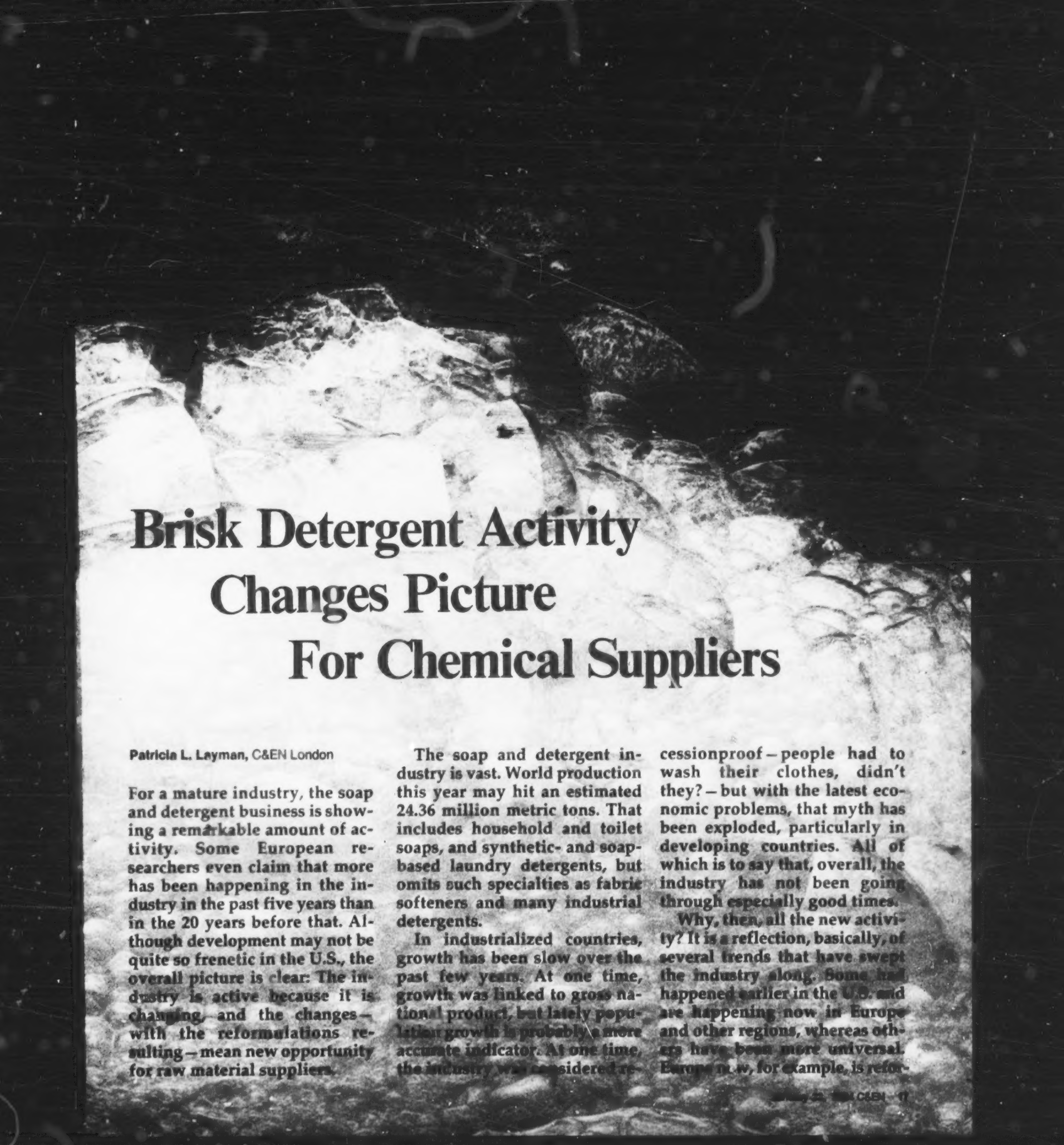
. . . with fastest increases in electrical and electronics applications . . .

Automotive	18	36	44	57	65	5.3	2.7
Appliance	14	21	26	31	40	3.6	5.2
Marine & plumbing	5	12	15	21	28	7.0	5.9
Electrical & electronic[d]	1	2	4	23	45	42.0	14.4
Household products	1	2	3	5	7	10.8	7.0
Other	1	2	3	5	5	10.8	0.0

. . . but with electroplating and electroless plating lagging in growth

Chrome plating	38	70	85	120	140	7.1	3.1
Other[e]	2	5	10	22	50	17.1	17.8

[a] Acrylonitrile-butadiene-styrene. [b] Film. [c] Acetal, acrylic, cellulose acetate, epoxy, nylon, polycarbonate, polyphenylene sulfide, polysulfone, polystyrene, and polyurethane. [d] Includes electromagnetic and radiofrequency interference shielding and includes products that could be listed under automotive and appliance as well as computer and video game categories. [e] Vacuum metalizing, sputter coating, hot stamping, zinc arc spraying, flame spraying, and spray-applied nickel-polyurethane and nickel-acrylic coatings. Source: Margolis Marketing & Research Co.



Brisk Detergent Activity Changes Picture For Chemical Suppliers

Patricia L. Layman, C&EN London

For a mature industry, the soap and detergent business is showing a remarkable amount of activity. Some European researchers even claim that more has been happening in the industry in the past five years than in the 20 years before that. Although development may not be quite so frenetic in the U.S., the overall picture is clear: The industry is active because it is changing, and the changes—with the reformulations resulting—mean new opportunity for raw material suppliers.

The soap and detergent industry is vast. World production this year may hit an estimated 24.36 million metric tons. That includes household and toilet soaps, and synthetic- and soap-based laundry detergents, but omits such specialties as fabric softeners and many industrial detergents.

In industrialized countries, growth has been slow over the past few years. At one time, growth was linked to gross national product, but lately population growth is probably a more accurate indicator. At one time, the industry was considered recessionproof—people had to wash their clothes, didn't they?—but with the latest economic problems, that myth has been exploded, particularly in developing countries. All of which is to say that, overall, the industry has not been going through especially good times.

Why, then, all the new activity? It is a reflection, basically, of several trends that have swept the industry along. Some had happened earlier in the U.S. and are happening now in Europe and other regions, whereas others have been more universal. Europe now, for example, is refor-

Glossary of soap and detergent terms

Actives. In a detergent, the surfactants that provide the cleaning action. Actives can be soap, or synthetic detergents, or a combination of the two.

Amphoteric surfactant. A surfactant that may be either anionic or cationic in water, depending upon pH. Frequently used in shampoos and other personal-care products because of mildness.

Anionic surfactant. A surfactant with a negatively charged anion incorporated into the molecule. Tends to be high-sudsing. Major anionics are linear alkyl-sulfonates.

Antiredeposition agent. More accurately, antisoil redeposition agent, an additive used to help prevent soil from resettling on fabric after it has been removed during washing. Sodium carboxymethylcellulose is the classic "antiredep" agent, but increasingly, more sophisticated cellulose derivatives and synthetic polymers are used.

Biodegradability. For the detergent industry, a measure of a surfactant's ability to decompose by biological processes, especially by bacteria present in waste-treatment systems, in surface waters, and in the soil.

Bleach. A material that whitens, removes stains, and brightens fabrics. Can be formulated into detergents or used as a separate product.

Builder. A material that improves the cleaning efficiency of a surfactant, principally by inactivating water-hardness ions. Can function as chelating and sequestering agent, as precipitating agent, or as ion exchanger. Used in virtually all home laundry powders and in many home laundry liquids for heavy-duty cleaning. Detergents formulated with builders are termed "built."

Cationic surfactant. A surfactant with a positively charged ionic group in the molecule. Not generally used for cleaning per se, rather for disinfectant-cleaners, and in fabric softeners. Quaternary ammonium compounds are most commonly used cationics.

Corrosion inhibitor. A material that protects against abrasion and corrosion of appliance surfaces, and protects china and metal washed in automatic dishwashers. Sodium silicate is the most commonly used corrosion inhibitor.

Enzymes. In the detergent industry, the amylase and protease enzymes used to catalyze biological decomposition of proteinaceous stains on fabrics, so the stains then can be removed by surfactants.

Eutrophication. The complex process of nutrification of a body of water. Nutrients from a variety of sources nourish algae in the water, causing them to flourish and eventually swamp the oxygen in the water otherwise available to decompose dead organisms. The result is, eventually, a sludgy, silting-up body of water. Necessary nutrients are nitrogen, potassium, and phosphorus; because detergent phosphates come from a highly identifiable and isolatable source, they frequently have been singled out as a major culprit in eutrophication. Hence the pressure for their banning in areas troubled with eutrophication.

Fatty alcohols. The primary alcohols of C_6 to C_{22}, usually straight chain, which are an intermediate for nonionic surfactants in particular. Historically derived from natural sources such as tallow and coconut oil; more recently primarily produced, by several different routes, from petrochemical raw materials.

Foam booster. An additive to boost suds production and stabilize lather. Alkanolamides are the most frequently used foam boosters.

Foam depresser. An additive to suppress or inhibit the production of suds or control suds at a low level. Soap, as part of a surfactant system, helps control foaming; silicone compounds, used at very low levels, are also effective foam depressers.

"Hard" surfactant. A surfactant difficult, or hard, to decompose biologically—that is, of low biodegradability. Branched-chain surfactants, in particular branched-chain alkylbenzene sulfonates, tend to be "hard," and came under fire in the early 1960s as contributors to foam in the waterways. Use in detergents was given up voluntarily by producers at that time in North America and Western Europe.

Heavy-duty detergent. Generally a built detergent, designed for cleaning the total family laundry, including heavily soiled items.

Light-duty detergent. Generally an unbuilt detergent designed for light cleaning tasks, such as hand dishwashing or fine-fabric washing.

Liquid hand soaps. Toilet soaps formulated as liquids rather than a bar. The term tends to be a misnomer, because, by and large, the formulations are based on synthetic detergents, although some products have been put together around potassium soaps.

Nonionic surfactant. A surfactant containing neither anionic nor cationic functional groups. Tends to be low-sudsing. Ethoxylated alcohols are the most widely used nonionics.

Saponification. The process of converting a fat, such as tallow, into a soap by treating it with an alkali such as sodium hydroxide. Yield is soap and coproduct glycerin.

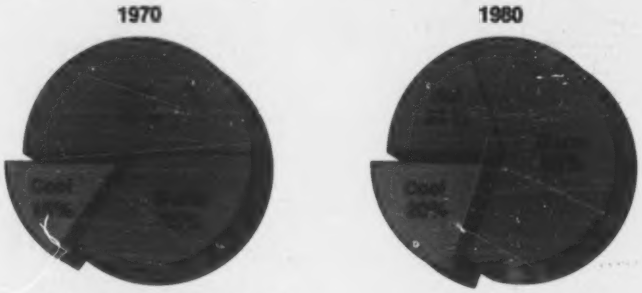
Soap. Reaction product of saponification. A mildly alkaline surfactant which, unfortunately, tends to interact with water-hardness ions, forming insoluble soap curd which precipitates out onto fabrics and appliances. Though not a problem in soft-water areas, soap-curd occurrence spurred the development of synthetic detergents, which are less affected by water hardness.

"Soft" surfactant. A surfactant that is relatively easy to biodegrade, thus the opposite of "hard" surfactant. Generally these are linear molecules, such as linear alkylsulfonates (LAS). Sodium dodecylbenzene sulfonate is the major compound within the LAS family of surfactants.

Surfactant. The common contraction for surface-active agent, referring to an organic compound that changes the properties of the surface of the liquid to which it is added. Detergent surfactants (and soap, which is also a surfactant) lower water's surface tension, enabling faster wetting of a fabric being washed. Soil can then be more readily loosened and removed.

Source: Soap & Detergent Association

Cooler water used in increasing percentage of washloads



Note: Hot = 127 °F, warm = 95 °F, and cool = 63 °F.
Source: C. A. Houston & Associates

mulating detergents to cope with lowered washing temperatures and the increasing share of the washload held by synthetic-fiber textiles, while handling the heavier soil loads commonly found with European washes.

More widespread has been the need to reformulate, or at least reevaluate, builder systems, as actions against phosphates continue in Europe and are rekindling in the U.S. after nearly a decade of calm.

And with the reformulations, the soap and detergent industry offers yet another example, that in new directions, it is the smaller company that takes the chances and makes the new-product introductions.

Given an industry as vast as soap and detergents, it probably is not surprising that it tends to be dominated on a world scale by a handful of companies. Looking strictly at soap and detergent sales, at the top of the pile is Procter & Gamble of Cincinnati. London-based Unilever is second. New York City-based Colgate-Palmolive is third, and Henkel of Düsseldorf, West Germany, is fourth.

Unlike the U.S. market, however, where P&G, Colgate, Lever, and the U.S. fourth, Purex Industries, totally dominate the business, on a worldwide basis, the international Big Four have less than half the market. The remaining share—about 53 to 55%, is split among innumerable small, local, or regional producers. In Europe, for example, the Association Internationale de la Savonnerie et de la Détergence, an association of European national associations in the industry, estimates that its member groups represent more than 700 detergent and soap makers.

Moreover, on a worldwide basis, the Big Four generally tend to do most of their business close to home. P&G's total sales, for example, are about 70% in the U.S. Unilever's are about 65% in Europe, and Henkel does about 80% of its business in Europe. Only Colgate has less than half its sales at home: about 40% in the U.S., and the rest split almost equally between Europe and the rest of the world.

The situation is somewhat different with raw material suppliers. There are a few small local or regional suppliers, but basically major national or multinational companies supply most detergent active ingredients, or formulating products such as builders, bleaches, and fillers. The major detergent producers provide such a large demand, suppliers have to be large to produce enough material to supply their big customers. Some companies have divisions to concentrate strictly on this market. BASF, for example, has just restructured some of its operations into a specialty chemicals—for example, detergents—division.

And because most of the active components in modern detergents are petrochemical-based, suppliers have brought along the economies of scale that always have accompanied basic petrochemical production.

Perhaps the trend having the most profound impact now on the soap and detergent industry worldwide is a move toward lower washing temperatures. This trend has been taking hold for a number of years in the U.S., of course, particularly as energy-conscious consumers seek to trim electricity bills for heating water.

But in the U.S., "hot" has always been a relative term: probably about 50 to 60 °C. In Europe and many other areas of the world, "hot" is 90 to 95 °C, often referred to as "at the boil." Bleaching systems were formulated originally for optimum performance at these temperatures, and the white cottons and linens used then came out sparkling clean. Energy-consciousness has hit the European consumer hard, however, and both detergent makers and washing-machine producers have been working to design systems that will do the bulk of a family's washload at 60 °C, with an increasing option of doing some of the wash at an even lower temperature, usually about 40 °C.

In that, the industry is approaching the level of that in Japan, where the usual laundry temperature is 30 °C or below. In Mexico, an even more extreme example, historically laundry has been done in cold water.

Temperatures as low as that pose challenges for detergent formulators whose palette up to now has been filled with materials that perform best in warmer water. Formulators have to make sure the active will dissolve readily in cold water—one commonly used surfactant in the U.S., for example, tallow alcohol sulfate, tends not to dissolve well in cold water. They must ensure that the bleach system will perform efficiently—perborate bleaches must have boosters or activators when put in products destined for cool- to warm-water washing, else lose much of their efficiency. They have to make sure the foam generated will be sufficient to assure the consumer that the detergent is working hard, but not so much that it overflows or clogs up a system.

Most detergents on the market are still aimed at the warm wash, although many packages, especially in the U.S., do note that the products are suited for cold-water washing. And Lever, of course, sells cold-water All in the U.S.

In Europe, cold-water washing per se is generally looked at askance. Out to prove that it can be a good market segment, however, is a small British manufacturer, Stridebond, of Newcastle-Upon-Tyne, which last summer introduced a cold-water liquid. The company decided upon liquids, after concluding that the powder-detergent market would be too difficult to break into, and built a plant capable of turning out 17 million lb per year of liquid detergent. The product works at temperatures up to about 60 °C, the company says, but its promotions are aimed at cold water—just above freezing, if need be, with the cool water saving both on energy and fabric wear-and-tear.

How successful Stridebond is with its Cold Force remains to be seen, of course. Some industry observers question the wisdom of going to a liquid formulation. Heavy-duty liquids have been quite popular in the U.S. detergent market, capturing just under 20%. But they have remained at that 20% for a while, and earlier predictions of 25 or 30% of the market were clearly too optimistic. And they have met with mixed reaction in Europe, where they probably hold no more than 8% of the heavy-duty detergent market, in value, and 5% in volume.

In France, liquids have been the consumers' darling, and now hold more than 10% of the market. But elsewhere, the picture is different. In the Netherlands, liquids' share of market is closer to about 4% and falling, in West Germany about 8%, and in Switzerland about 4%.

European researchers contend that the liquids simply are not so effective as heavy-duty powders, and that whereas the difference in performance might not be so noticeable on the lighter soils and lower wash temperatures of the U.S., they are decidedly noticeable under European washing conditions.

One area in which U.S. detergent formulations are moving closer to those in Europe and Japan is in the use of enzymes. These materials had found significant popularity in the U.S. and Europe during the 1960s, because of their ability to tackle proteinaceous and carbohydrate stains on laundry. Either as presoaks or formulated into laundry detergents, the materials could tackle and enzymically decompose for further cleaning such stains as blood, egg, gravy, and the like.

But then reports of skin and respiratory problems among production workers popped up. There were never any charges that the consumer would be harmed. Rather, the problem was with workers in detergent factories who inhaled the dust. The enzymes then used were very small particles, easily dustborne, and some of them, proteases, could attack the respiratory tissue. Consumer activists jumped on the issue and began campaigning against enzymes, government agencies began to worry about their use, and in early 1971 enzymes were pulled out of formulations. The detergent market for them collapsed.

Later that year, however, the U.S. National Academy of Sciences concluded that the average enzyme-containing detergent produced no more skin irritation than ordinary laundry products. Moreover, enzyme makers had developed new production methods to turn out enzymes that were low-dust, coated granules. That innovation resolved the problem of worker respiration.

In Europe, enzymes promptly were reincorporated into detergents, and now probably two thirds of all premium-quality heavy-duty detergents there contain enzymes. Japan's detergent makers reformulated all

Detergent formulations around the world have great variety

% of total formulation	Heavy-duty powders, U.S., Canada, Australia	Heavy-duty powders, South America, Middle East, Africa	Heavy-duty powders, Europe	Heavy-duty powders, Japan	Heavy-duty liquids	Light-duty powders (primarily Europe)	Light-duty liquids	Detergent laundry bars
Actives[a]	6–20%	17–32%	8–18%	19–23%	15–50%[b]	14–25%	15–37%	18–30%
Foam boosters[c]	0–2	—	0–3	—	0–4	—	0–5	—
Foam depressants[d]	—	—	0.3–5	1–2	—	—	—	—
Builders[e]								
Sodium tripolyphosphate	25–35	20–30	20–35	0–15	10–30	10–40	—	—
Mixed or nonphosphate	15–30	25–30	20–45	0–20	15–20	—	—	25–45
Sodium carbonate	0–50	0–60	—	—	—	—	—	15–30
Antiredeposition agents[f]	0.1–0.9	0.2–1	0.4–1.5	—	0–2	0–0.9	—	0.3–2.0
Anticorrosion agents[g]	5–10	5–12	5–9	15	2–5	0–8	—	3–8
Optical brighteners	0.1–0.75	0.08–0.5	0.1–0.75	—	0.1–0.5	0–0.3	—	0.05–0.3
Bleach[h]	[i]	—	15–30	—	—	—	—	—
Enzymes[j]	[i]	—	0–0.75	—	0–1	—	—	—
Moisture	6–20	6–13	4–20	—	Balance	6–14	Balance	3–14
Fillers[k]	20–45	10–35	5–45	—	—	15–45	—	See sodium carbonate
Other ingredients[l]	—	—	—	—	—	—	6–9[m]	15–20[n]

a Mostly alkylsulfonates (linear and branched), fatty alcohol ethoxylates, and fatty alcohol sulfates. b Includes up to 10% soap in European formulations. c Ethanolamides, such as cocomonoethanolamide. d In small levels, silicones; at higher levels, soap. e Some formulations use only sodium tripolyphosphate; others have mixtures of tripoly with other phosphates (for example, sodium orthophosphate), aluminosilicate zeolites, the sodium salt of nitrilotriacetic acid, sodium citrate, and sodium carbonate; still others use the other builders alone or in various combinations. f Sodium carboxymethylcellulose, other cellulose-based polymers, or synthetic polymers. g Sodium silicates (as purchased solutions). h In U.S., sodium perborate, when used. In Europe, formulations for high-temperature washing have sodium perborate, whereas those for use at lower temperatures include boosters such as tetraacetylethylenediamine. i A few formulations include 20 to 25% bleach and up to 0.75% enzymes. j As purchased granules. k Predominantly sodium sulfate. l Usually also include small amounts of coloring agents, opacifiers if desired, fragrance, etc. m Primarily viscosity builders. n Predominantly sodium bicarbonate, but can also include other filler materials such as kaolin and talc.

Detergent intermediates capacity far outstrips demand

Linear alkylate capacity (thousands of metric tons)

U.S. producers		Western Europe producers	
Vista (Conoco)	170	**Shell**	175
Monsanto	109	**Petresa**	150
Witco	20	**Chimica Augusta**	140
		Huls	80
		Montedison	35
		BASF	30
		Texaco	25
Total nameplate	**299**[a]	**Total nameplate**	**635**
Effective	**272**	**Effective**	**515**
Demand	**240**	**Demand**	**325**

Fatty alcohols capacity (thousands of metric tons)

U.S. producers		Western Europe producers	
Shell	210	**Henkel**	120
Ethyl	108	**Shell**	60
Vista (Conoco)	106	**Condea**	60
Procter & Gamble	98	**BASF**	12
Sherex	9	**ICI**	12
Celanese[b]	23	**PCUK**	8
		Chimica Augusta[c]	50
Total nameplate	**554**	**Total nameplate**	**322**
Effective	**390**	**Effective**	**305**
Demand	**210**	**Demand**	**160**

a Union Carbide closed down its 73,000 metric tons of capacity in 1983. b Retrofitted plant to be opened. c Rumored to be reopening plant now closed.

their major brands in about 1978 to include enzymes.

Progress toward their use in the U.S. has been slower, mostly because the term "enzyme" became such an emotionally traumatic one for the consumer. But detergent makers are putting them back into products, and enzyme makers have high hopes for the market. For example, one of the major enzyme makers, Gist Brocades of the Netherlands, several years ago put together a share issue to construct a new detergent enzymes unit at its Kingstree, S.C., plant. The company said at the time that U.S. demand for detergent enzymes eventually would far outstrip that of Europe.

One estimate holds that present sales of detergent enzymes make up 15% of total enzymes sales in the U.S., as detergent makers put them back into products. Contrary to several decades ago, there is little fanfare marking their reintroduction. And gone is the once-magical word "enzymes." Now a snappier, more specific "protease" or "amylase" does nicely for the detergent maker trying to put together a superior product.

If enzymes are still a controversial subject in the U.S., antisoil redeposition agents—better known as antiredep agents—are not. And researchers are finding this field a fertile one. The classic antiredep agent has been, and continues to be, sodium carboxymethylcellulose. But as with most of the classical detergent components, it was developed to perform on cottons and other cellulosics. Suppliers such as BASF and Rohm & Haas contend that this compound is less efficient in preventing soil redeposition on synthetics and blends. Their suggestion instead: polyacrylic acids and polyacrylates, from 1 to 6% in a formulation.

However, with the carboxylic acid group present, offering the potential to sequester troublesome water-hardness ions, producers of the polyacrylates see a possible market as a builder. After all, sodium citrate already functions as a sequestering builder in Lever Brothers' Wisk liquid detergent in the U.S. Polyacrylates probably would not be used as a sole builder, but as a cobuilder with other builder materials—with low-phosphate formulations, for instance, as the environmentalist campaigns against phosphates are rekindled in some areas in the U.S., and as phosphate limits are tightened in some European countries.

The most frequently used phosphate builder is sodium tripolyphosphate. Not only is it an excellent sequestering agent, but it helps during the manufacturing process. Because it forms a stable hydrate, it allows the product to contain relatively high amounts of moisture without sticking in the equipment. And because it has been used for so long, detergent manufacturers have essentially worked its cost into the selling price of laundry powders. Its cost-efficiency becomes the standard which other products must match or better.

The height of the controversy over phosphates in detergents in the U.S. came in the early 1970s. At that time, most of the localities in which there was perceived to be a problem with eutrophication of the waters passed their laws. Some banned phosphates altogether, either in automatic dishwashing detergents or in laundry detergents. Some states or localities set limits on the amounts of phosphorus that could be used.

Similarly, although at a somewhat later time, European countries that also perceived a problem with eutrophication of their waters put out limiting legislation. Most of the legislation put a phased reduction into effect. For example, in West Germany, sodium tripolyphosphate made up about 40% of a typical detergent formulation—10% phosphorus—in 1975, before the legislated limits went into effect. That was the equivalent of 270,000 metric tons per year of demand for tripolyphosphate. When the first stage of the reduction went into effect, the typical average dropped to 30% tripolyphosphate (7.5% phosphorus), or about 160,000 metric tons per year. The second phase went into effect Jan. 1 this year, and the average will drop to 20 to 24% tripolyphosphate (5 to 6% phosphorus), or about 120,000 metric tons per year of demand.

With those kinds of limits, or with the threat of phosphate bans increasing in number in the U.S., detergent makers are being forced to consider at least cobuilders to retain the cleaning efficiency of their brands, or are attempting to switch away from phosphates completely.

One of the first to switch away completely in the U.S. was Desoto

The heat once again is on phosphates

After a period of relative quiet, detergent formulators are facing an upswing in action against phosphate builders, both in the U.S. and elsewhere around the world. To some extent, it is a matter of beleaguered public officials seeking to attack what is still perceived to be a problem of eutrophication. It sometimes is also a matter of "politicking"—eager politicians courting popular approval by attacking an industry that is vast and very visible, even though such action may be unfounded.

In the U.S.: At the present, in the U.S., six states—Indiana, Michigan, Minnesota, New York, Vermont, and Wisconsin—ban the use of phosphates in home laundry detergents. And all six also limit the phosphate content, the equivalent of 8.7% phosphorus, in automatic dishwashing detergents.

Additionally, localities have their own bans. Dade County, Florida, which includes Miami, has a total ban, as do Chicago and many of its suburbs, and Akron, Ohio, and some of its suburbs.

Other areas have opted for limits. Connecticut, Florida, Maine, and about 15 municipalities limit phosphorus content to 8.7% in household laundry detergents. It will be limits, rather than a ban, in Maryland, if the new legislature starting up this month adopts a bill already filed with it to limit phosphates to a level to be set later on.

And in Ohio, two bills introduced in 1983 and scheduled to be carried over would prohibit the sale of household detergents containing more than 0.5% phosphorus. The ban would be effective for the 35 Ohio counties in the Lake Erie drainage basin.

In Canada: There is a federal limit on the use of phosphates in household detergents. The limit is set at 2.2% phosphorus.

In Europe: Phosphates vis-a-vis eutrophication is basically a regional, or national, issue rather than a pan-European issue suited for the European Economic Community; national or regional authorities have been responsible for tackling the problem in their own ways. Some countries, notably Sweden, have decided the best way to tackle water eutrophication is through tertiary sewage treatment systems. By the end of 1983, for example, Sweden had built more than 850 such treatment plants, and some 80% of the urban population of Sweden are connected to tertiary treatment systems. Most other countries that have a perceived problem, however, have turned to phosphate limitations.

For most countries, the limits set—and by and large, they are limits, not bans—are complex formulas dependent upon such factors as water hardness. For example, in West Germany, a decree has set the maximum amount of phosphates in detergents with scheduled reductions, in phases. The first reduction went into effect on Oct. 1, 1981, and the second stage began at the first of this year. A typical reduction: for water of 0 to 7 degrees German hardness (the equivalent of 0 to 126 grains in the U.S.)—that is, soft—a decrease from 0.7 to 0.5 g per L maximum phosphorus for home laundry detergents. Allowable limits are higher for harder-water areas. Rather than the solution being one of different formulations for different areas, however, there generally will be a standard formulation from each detergent maker, with a chart giving precise use rates for a washload in the various areas. The laundry-doer at home thus has the choice of supporting the limits, or of being a scofflaw.

In Italy, the government introduced a phosphates limit in March 1982, as part of a general law on the environment. And in the Netherlands, there has been a voluntary reduction in phosphate levels by the industry, in two stages. The latter stage went into effect Jan. 1, 1983.

Switzerland has perhaps the most severe problems with eutrophication, because of its geology. The country's legislators started in 1977 to determine legal limitations to phosphate content in detergents, and on Dec. 8, 1980, the federal government approved a two-stage reduction in limits. The first stage went into effect Oct. 1, 1981, and the second stage Jan. 1, 1983. But, again, the reductions were to a complex set of limitations, with a range of levels of phosphate allowed.

And in Norway, which also has special problems, particularly with its Lake Mjøsa, the industry and government worked out an agreement to limit phosphate content in household laundry detergents to 12% sodium tripolyphosphate. However, there is a total ban on the builders for automatic dishwashing detergents.

Phosphate reductions are currently under discussion in Austria, but no decisions have been reached. And in Finland, a gentleman's agreement between industry and government has limited phosphate content to the equivalent of 7% phosphorus.

In Australia: The topic of phosphate reduction is under discussion but there is some feeling that the problem is more political than actual.

In Japan: Although only some of Japan's prefectures have instituted bans on phosphate use, because of the country's marketing patterns, detergent makers decided upon total reformulations. As a result, within only two years, more than 90% of the detergents produced and sold in Japan are phosphate-free, built instead with zeolites.

Chemical, which makes all of Sears' laundry detergents. Desoto turned to using a sodium carbonate-built formulation in the early 1970s and has continued with that particular builder system.

Few other companies have followed Desoto's lead, however. Nor have many other manufacturers followed Lever Brothers, which reformulated its Wisk liquid detergent builder system from phosphates to sodium citrate.

A major builder to be tapped, either for use alone or with phosphates, has been the zeolite family. In Japan, for example, zeolites are the sole builder in more than 90% of all detergents sold.

Henkel has the patents nearly worldwide on zeolite builders, based on its technology for Sasil—sodium aluminosilicate—zeolites. It has licensed zeolite production to Degussa in West Germany and Italy, to Mira Lanza and Montedison in Italy, to Akzo and Zinkwit/Crosfield (a Unilever interest) in the Netherlands, and to PCUK/Rhône Poulenc in France, in Europe alone. As recently as August 1983, production capacity for detergent zeolites in Europe was at least 210,000 metric tons per year.

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(That includes 65,000 metric tons capacity at Henkel, strictly for captive use.)

Henkel also has licensed production elsewhere in the world—in Japan, for example. In the U.S., the patent situation is somewhat murky. It is a rather sore subject with Henkel researchers—"We filed four weeks before Procter & Gamble," one says—that it had been unable to win the U.S. patents, too.

In the U.S., capacity is dominated by Ethyl Corp., whose zeolites plant at Pasadena, Tex., went on stream in the late 1970s with capacity of about 100,000 metric tons per year. And PQ Corp. put on stream in September 1982 its 30,000 metric-ton-per-year plant in Kansas City, Kan.

So with that kind of capacity, just what is being done with zeolites? In Japan, a lot. In Europe, toes are in the water. In the U.S., not much.

Zeolite-built formulations, either using zeolite as a cobuilder with phosphates or as sole builder, in Europe are basically being sold only where there are phosphate limits. There would be little likelihood of finding them, for example, in the U.K., because there is no eutrophication problem there, hence no phosphate limits.

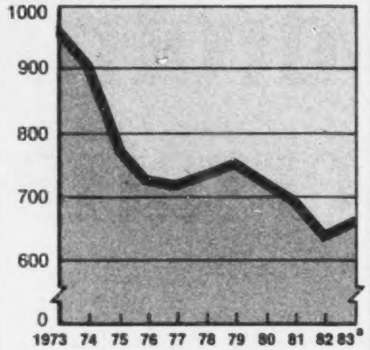
For the phosphate limit areas of Switzerland and West Germany, however, detergent makers are trying zeolites. After a limited test market in Luzerne, Henkel brought out a phosphate-free detergent, Dixan, in both Switzerland and West Germany. But rather obviously, the company still regards the product as having to prove itself. There has been little if any promotion to the effect that the product has no phosphates in it. The only clue is absence of the term "phosphates" on the contents label.

That perhaps is one indication that detergent makers still really don't think zeolites are the ultimate answer. It is one thing to predict, on a theoretical level, that losing the "freedom to formulate detergents with any safe and effective ingredient . . . will prove counterproductive to the consumers' interest in value for money," as did the chairman of the European detergent association's technical commission recently. But it is another thing to watch that counterproductivity in action in the marketplace, as market share is lost for a product whose performance has slipped.

Industry observers say that that is what led P&G to reformulate the zeolite-built products it had been marketing in phosphate-limit areas. Producers of zeolites in the U.S. had high hopes for P&G's success with the zeolite formulation. If P&G made it, the reasoning went, the market would quickly expand throughout the rest of the industry. P&G's reformulation, back to phosphates—to a level of 8.2% phosphorus, just under most of the limits of 8.7% phosphorus—dashed those hopes, and left some nearly new zeolite plants woefully underutilized.

Top detergent phosphate in U.S. has suffered decline

Sodium tripolyphosphate production, thousands of tons

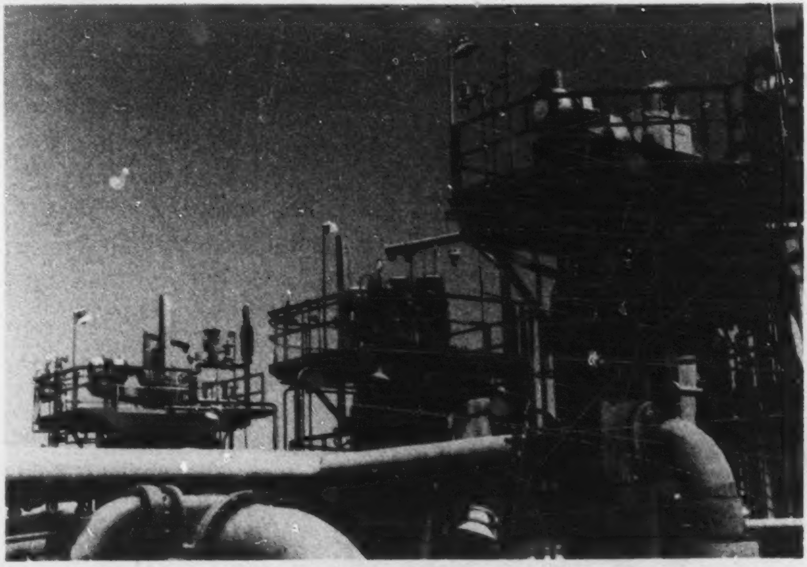


a C&EN estimate. **Source:** Commerce Department

On the other hand, P&G is continuing its limited test-marketing of sodium nitrilotriacetate (NTA) as a builder for detergents in Indiana, where phosphates are banned. It had been test-marketing detergents with NTA in New York state, another ban area, but backed off there in fear that the state would legislate a ban on NTA as well.

NTA has been tested and debated as a replacement builder since the early 1970s when the phosphate issue first arose. It is already in full use in Canada and in Finland. But because of early fears about carcinogenicity, or about heavy metals carried into the drinking water supply by superefficient sequestrant NTA, U.S. officials have never smiled on the material. The Environmental Protection Agency has said only that it sees no reason to ban the material, a statement far short of endorsement. However, the New York State Environment Commission has decided to look into the matter, and labor unions and consumer groups are still actively anti-NTA.

Consumers in Europe also tend to have a similar reaction to NTA, except in Finland. Perhaps for that politically powerful reason, most governments have advised caution over wholesale introduction of the builder as a replacement or an extender for tripolyphosphate.



Vista Chemicals' (Conoco) fatty alcohols plant, Lake Charles, La.

←CIRCLE 15 ON READER SERVICE CARD

The bleach dilemma: separate or united?

For the consumer, modern bleach systems are a vast improvement on the old standby of "lawn bleaching"—spreading laundry out on the ground to allow the sun to do the bleaching. But the washing habits of different countries have led to the development of two distinctly different philosophies of bleaching, one of adding bleach as a separate product, and the other of incorporating it into a laundry-detergent formulation.

For the U.S., the industry and consumers historically have tended to regard bleach as a separate item to be added along with the detergent, or used separately as a prelaundry soak.

In Europe, on the other hand, detergent makers have incorporated bleach into their formulations for many years. The German detergent maker Henkel's premier brand Persil, in fact, was a contraction of sodium perborate and sodium silicate, indicating the existence of bleach in the formulation when it originally was developed as a soap powder in 1907. (In 1909, the rights to the product and name were acquired for use in the U.K. by a company that subsequently became part of Unilever.)

Perborate as the bleach fit in nicely with European washing habits. The cottons and linens most common then could be put "to the boil," at 95 °C, at which temperature the perborate would be more than 90% effective as an oxygen bleach for wine stains and heavy soil stains. And even if lower temperatures were used, for the small percentage of the washload that was colored, the temperatures were still high enough that most of the perborate efficiency was retained. With that kind of formulation to depend upon, then, the consumer seldom needed special bleaching products, such as liquid chlorine. Chlorine, with its typical odor, came to be associated with disinfection, hospital cleaning, and other similar applications.

In the U.S., washing temperatures were never so high as those in Europe. More typically, "hot" was around 55 °C, and at such relatively low temperatures, perborate is only about 60% effective. Moreover, clothes and linens tended to be used for shorter periods of time before they were washed, so not all of them needed bleaching. Those factors encouraged the development of separate bleaches, for use only when an actual need was perceived. Several detergent brands are on the market in the U.S. with an oxygen bleach in the formulation—Oxydol, for example—but they aren't really typical.

In both the U.S. and Europe, the industry has been facing some problems with bleaching technology, for several different reasons. In the U.S., the rapid rise of synthetic fibers, which can be affected adversely by chlorine bleach, has given a boost to oxygen bleaches. Such products have been around for years, dry powders in the shadow of liquid chlorine bleaches.

And in Europe, a general drop in washing temperatures has meant a decrease in perborate bleach efficiency. Here, the answer has been the development of bleach activators, to help boost performance back to nearly the level of that "at the boil." Several boosters are being used in Europe: pentaacetyl glucose, frequently found in private-label brands, and tetraacetylethylenediamine (TAED). The TAED releases into solution the unstable peracetic acid, which becomes the bleaching agent at the lower temperatures.

Recycle unit at Interox's sodium percarbonate plant at Deer Park, Tex.—a U.S. beachhead

Oxygen bleaching in both the U.S. and in Europe has been the province of sodium perborate, and manufacturers of any other oxygen-bleach materials have had to struggle to gain acceptance.

A case in point is Interox, with its sodium percarbonate plant built in 1979 near Houston, and its other, specialty oxygen bleaches. Sodium percarbonate has been slowly gaining some use in Europe, in particular, but it may be in the specialty field that Interox has found a winner: with its magnesium monoperoxyphthalate hexahydrate. The material, which releases the peroxyacid anion in solution, has been adopted by Henkel for its new Fewa specialty detergent for delicate fabrics and hard-surface scouring cleansers. For products for use at higher laundry temperatures, however, European detergent makers are sticking solidly with perborate and TAED.

The West German government has probably come closest to tackling the issue. Last September, at the final meeting of the NTA Working Group, consisting of representatives of the Federal Ministry of the Interior and water supply authorities, among others, the group recommended an annual level of 25,000 metric tons of NTA be allowed in the environment. That would be equivalent to 3.4% NTA in a formulation. The group also recommended formulation of a monitoring program to measure the NTA in sewage, with a maximum limit of 0.2 mg per L.

A use level of 3.4% in a formulation would be too absurdly low to be effective, but as the number is an average, detergent makers could have more efficient levels in some formulations, and none in others.

The Netherlands also has set a maximum level on use of NTA—a 5% NTA average. But it also has set as its goal a total phosphates ban by 1987–88. As it stands now, there are no actual bans in Europe.

NTA producer BASF says that the monitoring program will be successful enough to encourage more widespread approval of the builder. Hence, its decision to start construction of a 36,000 metric-ton-per-year NTA plant in West Germany, to be finished by October 1984.

The evolution of surfactants continues after 40 years

The first synthetic detergents were introduced, in the 1930s, in areas where water hardness and mineral content were the highest, and the resulting soap curd problems the most severe. The surfactants were anionics—first, sulfated alcohols, and, later, sulfonated alkylbenzenes. As detergents continued to spread from hard-water areas to regions with softer water and less soap-curd occurrence, anionics consolidated this hold on the synthetic-detergent formulations.

The anionics had strong, rich lather, a characteristic that consumers already associated with cleaning efficacy. And they were, indeed, efficient cleaners of the fabrics found in the average washload—cottons, by and large. In 1950, for example, cottons accounted for more than 70% of the world's production of textile fibers, with synthetic fibers at about 18% and wool 10%.

By the early 1960s, however, detergent makers and intermediates suppliers had begun running into problems. First to hit the industry hard was the problem of biodegradability. The first generation of alkylbenzenes developed for sulfonation were branched chain, hard for microorganisms to break down in sewage disposal plants and in nature. Sewage treatment plants started seeing foam buildup as a result, and foam also began appearing in rivers and streams, and even from the household tap.

There was never a serious question of toxicity, just of the biodegradability of the materials. And in 1964, in the U.S., producers voluntarily agreed to switch their formulations to analogs of the branched-chain surfactants, linear alkylbenzene sulfonates. Similar actions took place in Western Europe at about the same time.

Anionics suppliers weathered that convulsive shift reasonably well. But the boom in synthetic fibers was another story. By 1964, synthetics had started serious growth, accounting for about 28% of the world's production of textile fibers. Cotton's share had begun shrinking, hitting about 62%. Seven years later, cotton was down to 50%, and synthetic fibers had jumped to 40%. Detergent makers decided that, as good as the anionics were at cleaning cottons, the nonionics were better at cleaning the synthetic fibers, and the rise in consumption of nonionics started to follow that of the new fibers.

Nonionics also got a boost—in the U.S., at least—from Shell's decision to build its 210,000 metric-ton-per-year detergent alcohols plant at Geismar, La., early in the 1970s. The plant, twice the size of any of Shell's competitors, helped lower the cost of nonionics—to a great extent, it still sets the price for the market—and the assured abundant supply and aggressive selling helped move the products into more general use.

Another plus was a better resistance to hard-water ions than the anionics, which helped them move into formulations when phosphate bans began hampering detergent efficacy. Since nonionics are easier to incorporate into liquid detergents than are anionic surfactants, they got a boost when liquid heavy-duty detergents began their dramatic rise in popularity in the mid- to late 1970s; from a 4% share of market in 1970 to now just less than 20% of the heavy-duty detergent market.

The 1980s, however, have brought a certain equilibrium to the industry. The shifts now will be horse-trading—a bit of a gain by nonionics at the expense of anionics, here; a bit of a gain by anionics at the expense of nonionics, there. In the developed countries, there is not that much growth these days to offer splendid growth opportunities for surfactants suppliers.

In the developing countries, on the other hand, there is still a strong growth, or a resumption of growth, after it was temporarily stifled by poor economic conditions. There is also a good deal of reformulation going on, as developing countries shift their production and consumption to biodegradable surfactants. Vista, for example, estimates that demand for branched-chain alkylbenzenes is still 456,000 metric tons per year, mostly in Latin America and the Far East. But even those markets are gradually eroding.

Although there is a global pricing pattern to the surfactant industry, little product actually travels back and forth, but rather is usually consumed close to where it is produced. One exception is branched-chain alkylates, for which the three major suppliers are Chevron, with a 130,000 metric-ton-per-year plant in Richmond, Calif., followed by Rhône Poulenc in France and Nippon Petrochemicals in Japan. Both of the two latter operations have some Chevron involvement. With that spread in geography, worldwide distribution is assured.

The other surfactants waiting for their time to come are those based on natural fatty alcohols. Such alcohols have been around for decades, of course, and long provided the only source of raw material for making detergent-range alcohols. But by 1970, the petrochemical products had started to make their inroads, and now naturals are only about a third of the business. Procter & Gamble, with its captive 98,000 metric-ton-per-year plant, and Henkel, with its estimated 170,000 metric-ton-per-year plant, both use natural feedstocks. Sherex uses naturals for its alcohols, and Condea in West Germany has about half its capacity suited for making alcohols from naturals.

There has been increasing interest in augmenting natural supplies in the past few years, although a variety of reasons has caused most such plans to be shelved. For example, Conoco Chemicals had completed an extensive engineering study for a natural-alcohol plant in the U.S. prior to its acquisition by Du Pont; that plan is now, at least for the time being, shelved at what has now become Vista Chemicals.

And Henkel had plans to build a plant with Union Carbide in the U.S., but that has fallen through. Henkel now is working out its next step, for acquiring detergent alcohols from whatever source for its U.S. operations; the company is tipped to be the partner for Celanese when Celanese retrofits its idle nylon-salts unit at Bay City, Tex., to make detergent alcohols from natural sources.

In theory, of course, naturals offer the lure of a continuing good raw material resource, renewable and manageable. But even the most enthusiastic boosters of the natural technology concede that it will be a long time before naturals return to a position of dominance over the industry or determine the pricing structure. There is simply too much synthetics capacity around now.

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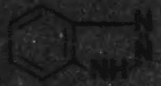

CAS 95-14-7

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NHCOCH3

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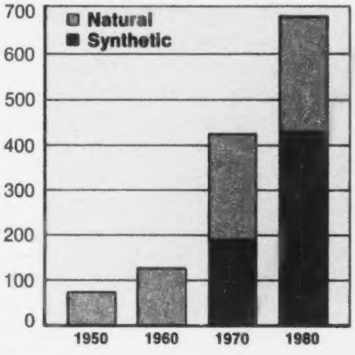
That is still quite a way into the future, though. More immediately, the reduction of phosphates is opening up a space in the detergent formulation that must be filled. Moreover, over the past few years, the percentage of surfactant in the formulation has been trimmed slightly, again opening room in the formulation. That, in turn, is putting increasing demand on producers of filler, or carrier, materials to help make up that 100% of product that goes in the detergent box. At the top of the list is sodium sulfate, a neutral, inert carrier for the active ingredients. Sodium carbonate could also be considered a filler, although it does have precipitating action against some water-hardness ions, so also functions as a builder. And in some products—laundry soap and detergent bars, for example—sodium bicarbonate is the filler of choice.

Soap bars and the increasingly popular synthetic detergent bars still are used heavily in developing countries. They provide concentrated detergents on the fabrics, with little waste, and are also easy to carry about. The other unusual—at least to western thinking—product form is found in Indonesia, which is a paste market. An error long ago in processing led to slurry-derived pastes of synthetic detergent being sold, and serendipitously, the Indonesian consumers liked the product. Paste it has remained ever since.

Indeed, perhaps because washing and doing the laundry are such a part of home life, habits tend to change only very slowly. Regulations could, presumably, force massive changes, but fortunately for the detergent industry, the industry has weathered governmental actions through shifts in ingredients, perhaps, but not drastic changes.

Synthetics dominate world output of fatty alcohols

Production, thousands of metric tons



Source: Industry estimates

The major directives affecting the detergent industry from the European Economic Community, for example, have covered the biodegradability of surfactants. The first such directive in 1973 covered anionic surfactants, to ensure that all anionics used be 80% biodegradable. The next directive, published in 1982, provided similar rules for nonionic surfactants. And a third for cationics is still under discussion. The industry is covered by EEC regulations and directives on dangerous substances—what is being used in the formulation and what must therefore be put on the package label.

But by and large, most of the directives (a less sweeping, urgent form of action than a regulation with EEC) pertain to the category of

Soap goes its own way

The industry tends to concentrate on the vast quantities and the more recent marketing excitement of the synthetic detergent part of the business. But soap continues to be a force that cannot be ignored.

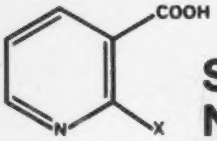
This year, there will be an estimated 6.96 million metric tons of soaps used worldwide. Admittedly, that is down from the 7.87 million metric tons of eight years ago. And most of the use is in the developing countries. The detergent industry in South Korea, for example, is dominated by soaps, as are those in many African countries. And abundant supplies of natural fats—tallow, for example—can lead to political endorsement of soapmaking, as in Latin America.

Nevertheless, even in the U.S., this year about 500,000 metric tons of soap and soap products will be used.

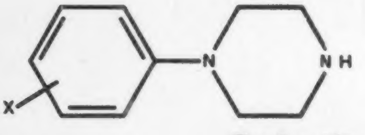
In the U.K., soap is the base of one of the country's leading heavy-duty laundry detergents, Unilever's Persil. Sold as a formulated soap powder, such a product is well suited to the twin-tub machines that still account for slightly more than half the washing machines found in the U.K.

HEXACHIMIE S.A.

BON-ENCONTRE, FRANCE



Substituted Nicotinic Acids



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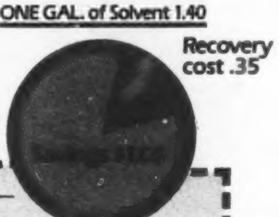

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packaging—determining package sizes, measuring weights and contents, and so on. Compared to everything else, that's merely a minor annoyance.

The soap and detergent industry over the past 40 years has gone through three major shifts. The earliest came shortly after World War II when the industry began a wholesale conversion to synthetic detergents, away from soap. The next shift was in the mid-1960s, away from branched-chain alkylbenzene sulfonates to the linear materials. The third was the march at least half way away from the anionic surfactants to the ethoxylated nonionic surfactants.

In two of those cases, the motion was welcomed by the industry—to synthetic detergents and to nonionics. But the other shift, away from branched-chain surfactants, was resisted early on by industry. Industry researchers at first were fighting the battle on suspected carcinogenicity grounds and only later realized the real front was biodegradability. The industry then voluntarily switched.

And now, the industry is in the midst of a fourth major shift, in the concerns over phosphates. Detergent makers argue that there is no strong move worldwide to ban phosphates from detergents because to do so would be too great a cost for the slight improvements in water quality that might result. These manufacturers have shown that in their industry publications, they say. But that misses a crucial point: Most consumers don't read industry publications, and environmentally active consumers don't believe such publications, no matter what their accuracy or truthfulness.

For the detergent industry, and for its suppliers, the present really important problems are those of capacities and profit margins. For suppliers, there is overcapacity for nearly all detergent intermediates. And much more likely than shutdowns of capacity is the prospect of more companies getting into the business—Celanese, for instance, with a retrofitted fatty alcohols plant soon to come on stream in the U.S., and Chimica Augusta under political pressure to reopen a now-closed al-

World production: growth is in developing countries

Thousands of metric tons	1976	1980	1984
North America	**5,398.7**	**5,432.0**	**5,530.6**
Soaps	507.3	532.7	557.1
Detergents	4,891.4	4,900.0	4,973.5
Western Europe	**5,298.4**	**6,064.0**	**6,575.0**
Soaps	891.8	823.4	765.8
Detergents	4,406.6	5,240.6	5,809.2
Eastern Europe	**2,962.0**	**2,736.8**	**2,750.0**
Soaps	1,273.7	1,171.8	1,120.7
Detergents	1,688.3	1,565.0	1,629.3
Latin America	**2,075.0**	**2,432.7**	**2,756.8**
Soaps	1,144.1	1,315.6	1,500.0
Detergents	930.9	1,117.1	1,256.8

Thousands of metric tons	1976	1980	1984
Oceania	**252.4**	**265.6**	**281.5**
Soaps	57.0	65.6	72.2
Detergents	195.4	200.0	209.3
Africa	**960.9**	**1,243.6**	**1,492.3**
Soaps	677.6	847.0	1,010.0
Detergents	283.3	396.6	482.3
Asia	**4,866.6**	**4,668.2**	**4,969.7**
Soaps	3,317.2	2,421.6	1,936.8
Detergents	1,549.4	2,246.6	3,032.9
GRAND TOTAL	**21,814.0**	**22,842.9**	**24,355.9**
TOTAL SOAPS	**7,868.7**	**7,177.7**	**6,962.6**
TOTAL DETERGENTS	**13,945.3**	**15,664.9**	**17,393.3**

Note: Detergents figures include compounded soap powders. **Sources:** Henkel, C&EN estimates. Original data available from Association Internationale de la Savonnerie et de la Détergence, and from national governments' statistics

cohols plant in Italy, with new technology to reduce the branching in its alcohols. Union Carbide's pulling out of the linear alkylate merchant business last year was a rare, but for the industry, blessed, exception.

As one supplier says, although there is structural overcapacity, normal competitive pressures have brought a balance to the industry to give a livelihood for everyone. It's not good enough for reinvestment, he adds, but not bad enough to precipitate rationalization. However, any major changes can only bring the market into shambles.

One of the hopes for intermediate suppliers is in price strengthening, but on the other side of the coin, detergent makers say they are hard-pressed to maintain margins, too. Competition from private-label and generic detergents has kept prices of the brand-name merchandise low, and in troubled economic times, consumers pinch their coppers.

The economy is picking up again around the world, nevertheless it will still be quite a while before anyone in the soap and detergent industry is making the "obscene profits" that many consumer activists love to rail against. ☐

Anionics dominate U.S. surfactant production

Millions of lb	1982 Production	 Merchant sales	 Sales value ($ millions)
AMPHOTERIC	**25.1**	**26.2**	**$ 28.2**
ANIONIC	**3054.8**	**1499.0**	**501.4**
Carboxylic acids and salts	802.6	121.6	77.5
Phosphoric and polyphosphoric acid esters and salts	28.9	23.4	21.9
Sulfonic acids and salts	1634.7	1118.5	254.9
Sulfuric acid esters and salts	536.7	206.5	130.8
Other	51.9	29.0	16.3
CATIONIC	**380.1**	**295.6**	**246.1**
Amine oxides and oxygen-containing amines	83.1	32.5	31.3
Amines and amine oxides	46.1	34.1	26.7
Amines not containing oxygen	61.8	55.7	53.4
Quaternary ammonium salts	155.7	141.8	109.0
Other	33.4	31.5	25.7
NONIONIC	**907.2**	**774.2**	**472.5**
Carboxylic acid amides	58.3	49.0	46.1
Carboxylic acid esters	210.3	171.6	130.9
Ethers	591.9	539.7	284.1
Other	46.7	13.9	11.4
TOTAL	**4367.2**	**2595.0**	**$1248.2**

Source: International Trade Commission

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JANUARY 30, 1984

CHEMICAL & ENGINEERING NEWS

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ACS spring meeting, St. Louis
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Farm markets spark big ammonia turnaround
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CHEMICAL & ENGINEERING NEWS

JANUARY 30, 1984

News of the Week

- **Chemical industry earnings more than doubled in fourth-quarter 1983.** **Page 6**
- **President's state-of-the-union address emphasized plans for a space station, preservation of the environment.** **Page 7**
- **Justice Department files lawsuit on behalf of EPA to recover cleanup costs of dioxin-contaminated sites in Missouri.** **Page 7**
- **Researchers succeed in growing whole plants that retain functioning foreign DNA segments from their host cell.** **Page 8**
- **Reagan backs claims that Soviets have breached arms control treaties.** **Page 8**

Business

Chemical stocks shift out of high gear, but they still performed better than most indexes in the past year. **Page 16**

International Business

Controversial new Soviet pipeline has begun channeling natural gas from Siberia to France. **Page 18**

Government

EPA's survey of groundwater pollution provides look at threat of pollution from surface impoundments; ACS sides with Monsanto in trade secret case now before Supreme Court. **Page 20**

Technology

Electrical separation process looks promising for phosphate mining ponds; nontoxic tracers proposed to monitor burning waste. **Page 23**

Science

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Preliminary Program

St. Louis will host the ACS annual meeting; 402 technical sessions cover a variety of topics. **Page 37**

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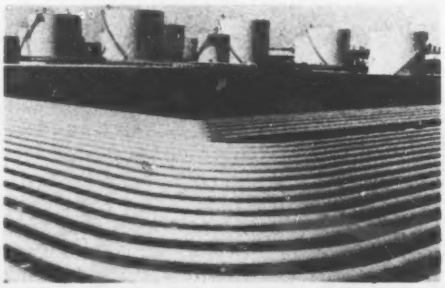


Cover Story

Petrochemicals are being helped by reviving farm markets, but imports may dampen prospects. Page 10

U.S. Farming Pickup Helps Natural Gas-Based Petrochemicals

Ammonia and urea will profit handsomely from turnaround in U.S. fertilizer markets, but imports loom as threat and already are hurting methanol

Bruce F. Greek, C&EN Houston

A much brighter year is shaping up in 1984 for some of the leading small-molecule commercial chemicals made from natural gas—after severe problems a year or two ago. But in the long run, U.S. producers of these chemicals could still lose, and are beginning to in some major cases, because of tough, fast-growing competition from natural gas-producing regions abroad.

That is the somewhat bittersweet outlook for ammonia, urea, methanol, and formaldehyde, whose immediate market prospects appear on the following pages. Three of the four chemicals will do well in revived farm markets and a continued strong construction market. Unfortunately, the fourth—methanol—is caught in foreign trade problems that could foretell problems for ammonia and urea as well.

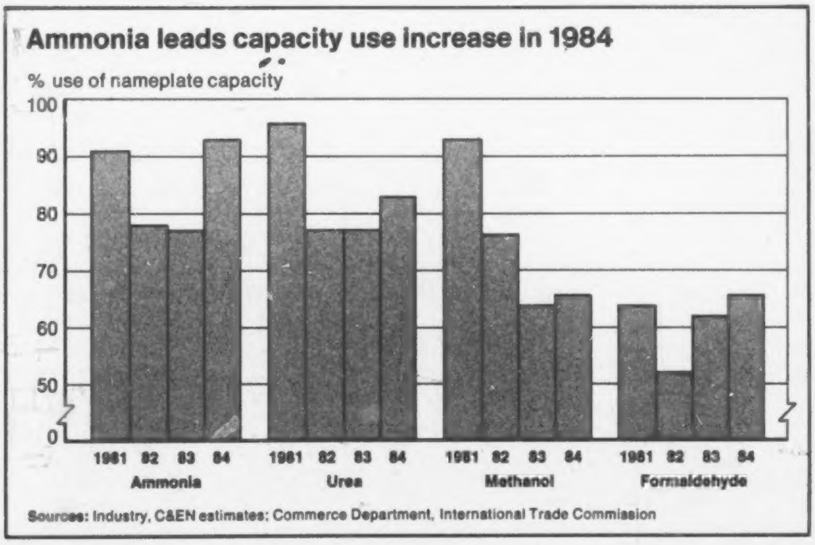
The big fact of commercial chemical life in the 1980s for products such as these is the dramatic rise in non-U.S. production using ultracheap natural gas, especially in Canada, Mexico, and the Middle East. For methanol, a significant and possibly ever-growing share of the U.S. market will be supplied by imports from these countries. The exact size of import growth is difficult to pin down because of potential alternative markets in other countries for methanol that might come into the U.S., other possible uses of the raw material gas in the producing countries, and future production costs of methanol in the U.S. But so far, U.S. methanol imports are zooming, and U.S. producers are hurting.

Key Chemicals

Formaldehyde to date is the great exception to such trade woes and has shown a fairly normal recovery since early 1983. Large-scale formaldehyde imports are considered very unlikely because technology to convert methanol to formaldehyde is simple and shipping costs high. In other words, formaldehyde will tend to be made close to where it is used.

Ammonia has no such long-run trade barrier but is free of trouble for the moment. In a stunning reversal from a year ago, the pungent chemical is headed for a near bonanza, in part because a capacity squeeze is due after widespread plant closings. Everything is going right on the farm in 1984, where most ammonia winds up. The end of the government's acreage-crimping payment-in-kind program promises a catch-up year in fertilizing that will greatly boost ammonia and, to a lesser extent, urea.

However, urea too underscores the threat of imports, which are holding down its production gains even now and could top urea exports this year. Foreign production of nitrogen fertilizers from low-cost gas could keep these imports of ammonia and derivatives such as urea on a sustained rise. Beyond 1984, the U.S. could become a net importer of nitrogen fertilizers after being a vigorous net exporter in the past. One result could be another round of ammonia plant closings. Roughly a third of the U.S. ammonia capacity has been shut down already over the past five years. Should the present surplus of U.S. natural gas be worked off in a few years and prices rise, much additional ammonia capacity, and along with it urea capacity, also could be scrapped.



Ammonia leads capacity use increase in 1984

Sources: Industry, C&EN estimates; Commerce Department, International Trade Commission

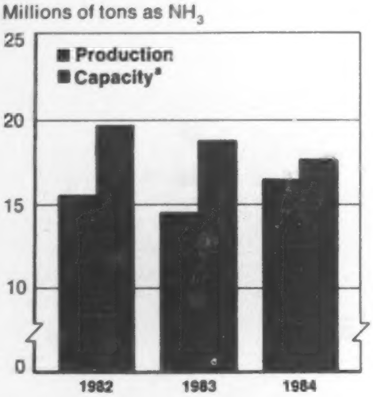
Key Chemicals

Ammonia

NH_3

- ***Demand jumping***
- ***Capacity falling***
- ***Prices rising fast***

PRODUCTION/CAPACITY



[a] First quarter; substantial capacity still shut down with scrappage expected to continue.

HOW MADE

Catalytic reaction of nitrogen from air and hydrogen from natural gas

MAJOR DERIVATIVES (U.S.)

Nitric acid 20%, urea 20%, ammonium phosphates 15%

MAJOR END USES (U.S.)

Fertilizer 80%, fibers and plastics 10%, explosives 5%

FOREIGN TRADE

Exports—down sharply to less than 0.5 million tons, imports—steady between 2 million and 2.5 million tons

PRICES

List prices rising from $150 per ton on Gulf Coast

COMMERCIAL VALUE

$3 billion for production, 1984

A banner year sums up the 1984 outlook for ammonia. Subject to the vagaries of world markets, production of feed grains in the U.S. will run all-out this year. To achieve this output, farmers will have to add heavy amounts of nitrogen fertilizer to the soil this spring. And nitrogen fertilizer means almost exclusively ammonia and its derivatives.

For ammonia producers, the current outlook is an almost unbelievable turnaround from the product's wretched performance a year or two ago, when prices collapsed and plants came down by the dozen. Companies' capacity trimming at the time has a lot to do with tight market conditions expected in 1984. Actual ammonia output will remain at least 15% below the record 19.7 million tons in 1980.

At the moment, practically all operable ammonia capacity is either running or in startup. Some additional capacity that is not now operable also may be undergoing modification and repair and will run as soon as possible. How much ammonia will be produced during calendar 1984 is difficult to forecast because of these capacity unknowns.

As much as 1 million tons per year of capacity carried in C&EN's total of 17.8 million tons possibly will not operate again, but until 1984 is over, it will be hard to tell. If none of this capacity comes on and the average operating rate is a very high 95% of nameplate capacity, then about 16 million tons of ammonia could be produced. One industry expert predicts this level of operation is about all the industry could do.

More likely, some of the very marginal capacity actually will run because of the probability of much higher prices and because of continuing lower prices for surplus natural gas. Pressure from these high selling prices and very strong demand this spring also will cause some existing capacity to be debottlenecked, letting it run above rated capacity. As a result, ammonia production could reach 16.5 million tons.

This production level will be 2 million tons, or 14%, more than badly depressed 1983 production and 1 million tons over 1982 output, when inventories ballooned. But the new boom still will not meet expected demand for ammonia and its derivatives. Helping to close the gap will be net imports of anhydrous ammonia of at least 1.5 million tons. Imports of other nitrogen-containing fertilizer materials also will be up, but exports of nitrogen fertilizers are expected down again except possibly for ammonium phosphates. So analysts forecast small net imports of nitrogen fertilizer materials in 1984—a sharp contrast to bulging net exports in recent years.

Needless to say, inventories of ammonia and derivatives are expected to be down substantially this spring. As much as 1 million tons of fertilizer materials (in terms of nitrogen) will come from this source. By the end of the fertilizer year (June 30), analysts predict nitrogen inventories of about 1 million tons in all forms—very snug compared to past levels.

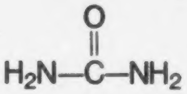
This inventory drawdown, the push on production, and net imports provide obvious clues to pricing. Prices moved up to about $150 per ton of ammonia in January from $115 a year ago, and everyone in the industry expects further increases. Actual prices will depend heavily on the weather this spring. If the planting season starts early, pressure on ammonia and derivative fertilizer supplies could be heavy, pushing prices temporarily quite high, followed by a slump in the summer. If the planting season is normal or a bit late, distribution problems and price pressure for ammonia and derivatives will be less but still substantial, analysts say.

Nonfertilizer uses of ammonia and derivatives account for about 20% of total U.S. demand. Feed additives, known generally as nonprotein nitrogen products, take less than 5% of ammonia demand and are quite mature (slow growing) products. Explosives, mostly used in mining, take another 5%. Polymers for fibers and fabricated plastics take most of the rest. None of these uses, although expanding in the economic recovery, will grow enough to pull ammonia away from agriculture.

Overall, for ammonia producers, 1984 will be a boom year after several tough ones. Even so, ammonia output will be far below previous records because of the severe cuts in capacity.

Key Chemicals

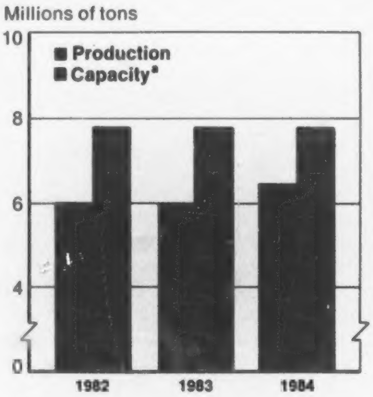
Urea



$$H_2N-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2$$

- ***Demand improving***
- ***Capacity flat***
- ***Prices rising***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Reaction of ammonia and carbon dioxide under pressure

MAJOR DERIVATIVES (U.S.)

Urea-formaldehyde resins 5%

MAJOR END USES (U.S.)

Fertilizers 80%, animal feed 10%, adhesives and plastics 5%

FOREIGN TRADE

Exports—flat, about 1.25 million tons in 1984; imports—rising to more than 1 million tons

PRICES

$130 to $150 per ton on Gulf Coast

COMMERCIAL VALUE

$1 billion for production, 1984

Urea will participate in the expected fertilizer boom of 1984 but not to the extent of ammonia. The main reason is that urea, a relatively simple derivative of ammonia, has become more of a world commodity than has its parent chemical. Such large quantities of urea are made outside the U.S., that international trade, including major imports into the U.S., influences U.S. urea production as much as does demand in the U.S.

U.S. urea production is expected to increase less than 10% in 1984, by about 500,000 tons to a total of 6.5 million tons. This gain follows two years in a no-growth trough.

But production could go higher, some analysts point out. Urea could act as a major swing product in meeting U.S. demand for nitrogen fertilizers this year. A larger than expected jump in demand could result from higher farm commodity prices, the end of the government's payment-in-kind program, and an effort to reverse reduced yields in 1983 due to the drought.

Traditionally, U.S. urea enjoyed large net exports. Farmers in many other countries favored urea over other nitrogen fertilizers for ease of handling. Until urea production began in areas such as Trinidad, Mexico, Canada, the Middle East, and Eastern Europe in the past five years, the U.S. dominated urea trade. However, urea production has jumped in many of these regions, which have low-cost natural gas. Imports now are rushing into the U.S., partly to fill expected demand for nitrogen fertilizers but also to take advantage of the strong dollar. In 1984, analysts say U.S. urea trade could balance or possibly go slightly into net imports.

What a contrast to urea's export strength of just a few years ago, which was a major influence in the product's all-out operation from 1979 through mid-1981. In 1980, exports jumped nearly a third to close to 2 million tons. But the boom broke late the next year, and for 1984 analysts expect exports down almost 40% from the peak to about 1.25 million tons.

This radical change in trade means that U.S. producers must sell more of their output in the U.S. market and face greater competition. This accounts for the relatively lower operating rate for urea plants compared to ammonia. If 1984 urea production reaches 6.5 million tons, nameplate capacity will run at about an 84% rate, probably 10 percentage points below the rate for ammonia.

As with ammonia, a lot of urea capacity has been shut down. Of this, more than 1 million tons has been scrapped in recent years. Some of the listed 7.8 million tons of capacity also could be headed for scrap and will not run at all during 1984, even with strong demand for nitrogen fertilizers. Again as with ammonia, it will take much of 1984 to tell what actual operable capacity for urea really is.

Ironically, despite these capacity questions, the longer-term demand curve for urea shows faster growth than for many other forms of nitrogen fertilizer. Both solid urea and urea in solutions, usually with ammonium nitrate, continue to find strong acceptance by farmers because of easy handling and good agronomic results. This growth is expected to hold up, probably because of farmers' preference for urea over direct application of anhydrous ammonia.

Nonfertilizer uses of urea are about a fifth of total use. Feed additives are the largest, but are not growing much, cycling up and down with changes in cattle numbers in feedlots.

Urea also goes into important commercial polymers. The urea-formaldehyde polymers' volume runs five to six times that of urea-based melamine. All these polymers go largely into construction uses, so the outlook here will follow the plateauing housing market. Simplicity of the polymerization process allows producers to run plants lightly or heavily as demand requires.

Since housing markets may be leveling off, nonfertilizer uses of urea will not have much impact on total demand in 1984. Analysts don't foresee major long-term influence on total demand either, because of these uses' relatively small size and cyclical nature.

On balance, then, urea faces a better year mainly because of strong U.S. fertilizer demand. But the big news of 1984 could be that producers find net imports in their foreign trade.

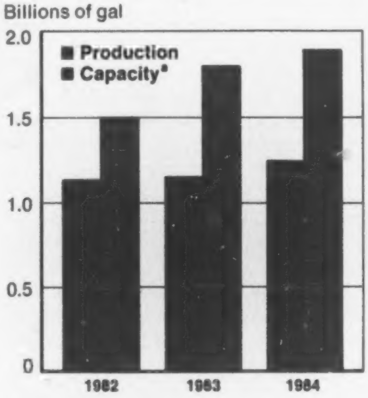
Key Chemicals

CH_3OH

Methanol

- ***Demand weak***
- ***Capacity leveling off***
- ***Prices way down***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Reaction of carbon monoxide with hydrogen made by reforming natural gas or heavier hydrocarbon fractions; or by coal gasification

MAJOR DERIVATIVES (U.S.)

Formaldehyde 30%, acetic acid 10%, methyl tert-*butyl ether 10%*

MAJOR END USES (U.S.)

Polymers used as adhesives, fibers, and plastics 50%

FOREIGN TRADE

Exports—declining to about 50 million gal in 1984, imports—rising to about 150 million gal

PRICES

List prices slashed to 45 cents a gal

COMMERCIAL VALUE

$550 million for production, 1984

Methanol's main note in 1983 was a sad one—lack of participation in the general recovery in U.S. chemicals production. The reason is the same as for urea's problems, only more so: a major shift in foreign trade, perhaps a harbinger of things to come for other leading organic chemicals.

Production of methanol in 1983 probably just about matched that in 1982, about 1.14 billion gal. The government's official 1982 production figure is some 7.56 billion lb, according to the International Trade Commission. Industry analysts expect the difference for 1983 to be no more than about 2% when final ITC figures are in.

In 1984, some further increase in methanol production is expected because of the continuing economic recovery and increasing newer fuel uses. The gain, however, won't be much even though this commodity is starting a year behind most other chemicals. Current consensus puts 1984 methanol production 5 to 10% higher, to bring the total to about 1.25 billion gal. Some pessimists believe growth will be less than 5% in 1984 because big methanol uses might not perform so well as expected in a slowing economic expansion.

At such a pace, methanol will certainly not lack capacity. At present, counting some units shut down for more than a year, swollen U.S. capacity is above 1.9 billion gal a year. If 1984 production reaches 1.25 billion gal, the industrywide average operating rate will be just 66%, barely up from 64% last year.

In 1983, probably 500 million gal of methanol capacity didn't operate. Some of this was shut down all year, and the remainder operated intermittently. Hence, the actual average operating rate at plants still running was much higher, probably about 88% of nameplate capacity. The same plant split will prevail in 1984.

The availability of additional capacity keeps severe downward pressure on methanol prices. List prices in many cases were slashed in 1983 to reflect actual selling prices more closely. The new low prices hardly increased sales of methanol at all. They did, however, underscore why some units were down for the whole year or significant parts of it. Prices in the 40 to 45 cent-per-gal range for large volumes at the producing plant site are about the cash cost of production, according to one industry analyst. No return on investment results from such prices for merchant sales. Hence, only if a company can convert methanol to derivatives can it justify having a methanol plant, unless the plant has been fully depreciated or the company can find natural gas at distress prices in the current surplus.

During 1983 a big shift in methanol foreign trade forced an extra 100 million gal or so of U.S. production into the U.S. market. Production as a result stood still even though U.S. consumption went up. A similar impact on production could occur in 1984, holding down production gains.

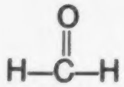
Changes in the end-use pattern of methanol are expected to be small during 1984. In general, all uses will grow in line with the economy. The largest uses, formaldehyde and acetic acid, are heavily dependent on home building. Forecasts for home building and commercial construction are for a static 1.7 million housing starts and about the same square footage in commercial building as in 1983.

Fuel uses, including fuel components such as methyl *tert*-butyl ether (MTBE) used as antiknock additives in unleaded gasoline, could have the highest growth rates among methanol uses in 1984. (Many people concerned with methanol consider MTBE a chemical use even though its only significant outlet is in gasoline.) One drawback, though, is that some gasoline blenders have found a way to lower their costs by adding methanol as pure fuel costing half that of other gasoline components. The problems motorists encounter with these gasolines tend to give all uses of methanol in gasoline, for example as a cosolvent with *tert*-butyl alcohol, a bad name. Such an image problem could put a damper on the overall growth of methanol use in fuel.

So for 1984, methanol won't make much headway in getting plant use back up, and imports will eat up a bigger share of U.S. demand. Prices barely covering operating costs will cancel financial returns.

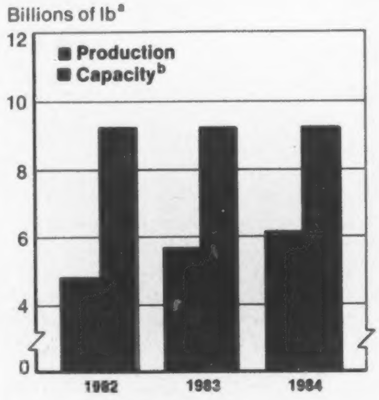
Key Chemicals

Formaldehyde


$H-\overset{\overset{O}{\|}}{C}-H$

- ***Demand surge slowing***
- ***Capacity flat***
- ***Prices steady***

PRODUCTION/CAPACITY



a As a 37% solution. b First quarter.

HOW MADE

Catalytic oxidation of methanol

MAJOR DERIVATIVES (U.S.)

Urea-formaldehyde resins 25%, phenol-formaldehyde resins 20%, polyacetal 5%, butanediol 5%

MAJOR END USES (U.S.)

Adhesives 60%, plastics 15%

FOREIGN TRADE

Negligible

PRICES

List prices about 9 cents per lb; merchant volume small

COMMERCIAL VALUE

$500 million for production, 1984

A cursory look at 1983 production data for formaldehyde and methanol suggests that something is amiss. Formaldehyde production increased 19%, whereas methanol production just about stood still. Yet, commercial U.S. formaldehyde is made only by oxidizing methanol, so additional methanol must have come from somewhere. The answer is methanol's nemesis of the 1980s—a big net increase in imports, which analysts estimate at about 100 million gal.

As a result, formaldehyde production recovered well in 1983, rising to about 5.7 billion lb (as a 37% solution). This production increase wiped out the recessionary decline of 1982, when production dropped to 4.8 billion lb from 5.7 billion lb in 1981.

In fact, production did better in 1983 than most industry analysts expected. They had forecast gains as 1983 opened ranging from 0.6 billion to 1.0 billion lb, with most opinion around 0.7 billion lb. The optimists may have an even better case. Although final production numbers still are months off, a strong October suggests that the full-year increase could hit 1 billion lb, possibly more, after an especially high fourth quarter.

For 1984, analysts' growth expectations for formaldehyde have cooled. Growth still is expected, but not nearly so much as in 1983. A consensus holds that another 400 million lb of production, or 7%, will appear in the total in 1984, bringing it to 6.1 billion lb. Possibly 10% growth is possible if the housing industry continues strong.

Average plant operating rates for formaldehyde are still low. In 1983, the rate was about 62% of estimated nameplate capacity. This is an inexact number because of the large number of small plants, which make capacity estimates difficult. For 1984, the operating rate likely will rise to just under 70%.

Some formaldehyde capacity may be shut down permanently, but not announced as such. Current capacity estimates probably are 5 to 10% overstated. New formaldehyde plants are unlikely to be built soon unless a special situation develops for a use in a location beyond economical shipping distance from an existing plant.

Obviously, with these low operating rates, many plants were run just part time. There are many variations in operating methods and in meeting captive needs for formaldehyde. Most formaldehyde is used at the production site but under some circumstances a producer of a derivative might find it less expensive to buy from a nearby formaldehyde plant and pay shipping charges even though the solution-type product is largely water.

The upswing in production in 1983 and 1984 continues despite lack of a final government decision on regulating formaldehyde because of possible irritation to tissues or carcinogenic effects. At this time, analysts won't guess the impact of any such regulation on production and use of formaldehyde.

Whatever, formaldehyde volume in 1983 roared back with the recovery in housing, which requires formaldehyde in several major resins used in adhesives and plastics. Resins made with either phenol or urea account for almost half of total formaldehyde use in the U.S. Most of these resins go into particle board, plywood, insulation, and other materials for housing. New housing starts in 1983 about doubled from 1982, pulling down bloated inventories of plywood and the like and restarting producers' inventory building. Currently, some industry analysts believe inventories of these building materials are too high, although others think that inventories are normal for the beginning of the building season.

Other uses of formaldehyde such as engineering polymers—the polyacetal resins—also are recovering pretty well as their markets in housing, appliances, and automobiles pick up. Many of these uses are relatively small, and some are developing much more rapidly than others. All are cyclical and depend on the health of the economy for strength in demand. None will cause unusual jumps in overall formaldehyde demand in 1984.

For 1984 then, formaldehyde will ride with its established uses, a majority of which go to housing. Since housing is expected to continue strong for most of the year, use of formaldehyde likely will increase further after a surprisingly strong 1983.

Chemicals' lead in stock market narrows

Early last fall, chemical issues were outpacing the stock market like Ferraris racing Fords. A few other major stock indexes were moving fast then, true, but around August the chemical group discovered a high gear that the overall market lacked. Thanks to that burst of power, C&EN's chemical stock index stood almost 55% higher by Oct. 8 than it had a year earlier. The Dow Jones Industrial Average, by comparison, had risen a comparatively puny 29% during the preceding 12 months of stock market rally.

Those high-performance days seem over now. During November and December, the Dow Jones average more or less maintained speed. Chemical stocks, on the other hand, slowed markedly. Between Jan. 21, 1983, and Jan. 20, 1984, the Dow Jones average rose from 1052.98 to 1259.11, an increase of about 20%. During the same period, C&EN's chemical stock index climbed about 22% from 218 to 265 (1954 = 100). Chemical stocks as a group still are outperforming the top stock market indicators, but not by nearly the same margin as before.

In fact, that margin is likely to narrow. Jack Henry, chemical industry analyst for E. F. Hutton, predicts that chemical stocks will perform at about the level of the market for the bulk of 1984. Other securities analysts are taking a similar stance. Oppenheimer & Co., for instance, is carrying no major chemical companies on its recommended list.

It's not that analysts are worrying whether chemical earnings will continue to be vigorous. Hutton's Henry, for one, still forecasts an average earnings gain of 30% in the chemical industry in 1984. Oppenheimer chemical analysts Richard A. Derbes and Charles J. Rose predict that in 1984 earnings will be up 20% at Rohm & Haas, 21% at Witco Chemical, 22% at Nalco Chemical, 32% at American Cyanamid, 34% at Reichhold Chemicals, 34% at PPG Industries, and 36% at Allied.

The problem is that stock prices are very likely already high enough to accommodate the probable scale of chemical earnings increases in 1984. Henry notes that during the third-quarter 1983 stock price surge, analysts probably overestimated 1984 chemical earnings. The result: "Stock prices have already fully discounted those expectations," he remarks.

Other stock analysts substantially agree. For example, Oppenheimer's Derbes recently increased his forecast of Rohm & Haas 1984 earnings in anticipation of continued benefits from reduced costs and a recovery in the agricultural sector. "The stock is not on our recommended list," he points out, however, "because we believe its current value fairly reflects its future prospects."

Nor is there much expectation among industry watchers that earnings will surprise them by growing more than is now forecast, a development that might lead to another stock price surge. There are two major reasons for this. For one, producers will continue to have trouble raising chemical product prices aggressively this year because of weak feedstock costs, a generally disinflationary attitude downstream, and tougher competition from imports. The import problem ties into the second reason, the strong dollar, which will reduce exports and undercut the kind of volume growth that normally would be expected in a year in which gross national product is forecast to rise 4 to 4.5%.

Still, performing at the level of the market may not necessarily be bad. There are a good number of stock analysts who believe that the current bull market, which began in August 1982 and seems to have been running out of steam lately, will surge again through at least the first three quarters of this year. They base their optimism on factors like rising productivity, lower inflation, and the somewhat mystic relationship between Presidential election years and stock market performance—usually a positive one.

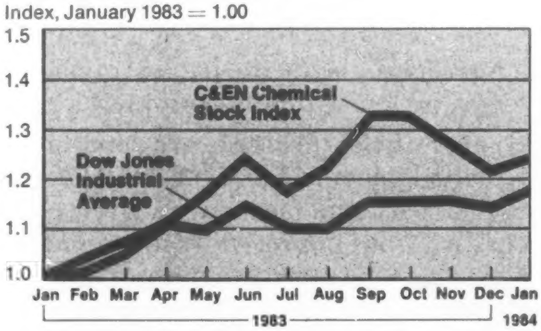
But all these calculations lie in the long shadow of the federal deficit. For all the optimism of the Administration, many analysts are deeply worried about the deficit, and figure that 1985 could very well put an end to the current recovery. For market-level performers, as chemical stocks are likely to be, such general expectations in the investment community could bode ill. □

Chemical stocks have performed better than most indexes in the past year. . .

	Jan. 20, 1984	Jan. 21, 1983	% change
C&EN Chemical Stock Index[a]	265	218	21.6%
Dow Jones Industrial Average	1259.11	1052.98	19.6
New York Stock Exchange Composite	96.13	83.18	15.6
New York Stock Exchange Industrials	112.22	95.23	17.8
American Stock Exchange Index	226.71	182.78	24.0
Over-the-Counter Composite	284.41	243.97	16.6
Over-the-Counter Industrials	329.44	292.50	12.6
Standard & Poor's 500	166.21	143.85	15.5
Standard & Poor's 400 Industrials	187.43	161.71	15.9

[a] C&EN index based on stock prices for Allied, American Cyanamid, Celanese, Dow Chemical, W. R. Grace, Monsanto, and Union Carbide.

. . . but last fall's glory days seem unlikely to be repeated soon



Note: Both indexes reindexed to January 1983 = 1.00 to make comparable. Based on mid-month stock data.

Soviet Gas Pipeline to Europe Starts Up

Siberian natural gas now is being piped to France, according to Gaz de France, the country's national utility. Deliveries likely will amount to 35 billion cu ft this year.

There is no way of verifying whether the gas indeed has its origin in the Yamal peninsula area, site of a massive natural gas deposit being developed by the Soviet Union. The Soviets claim it does, honoring a 1982 contract signed with the French which calls for their purchase of up to 282 billion cu ft annually over a 25-year period beginning Jan. 1.

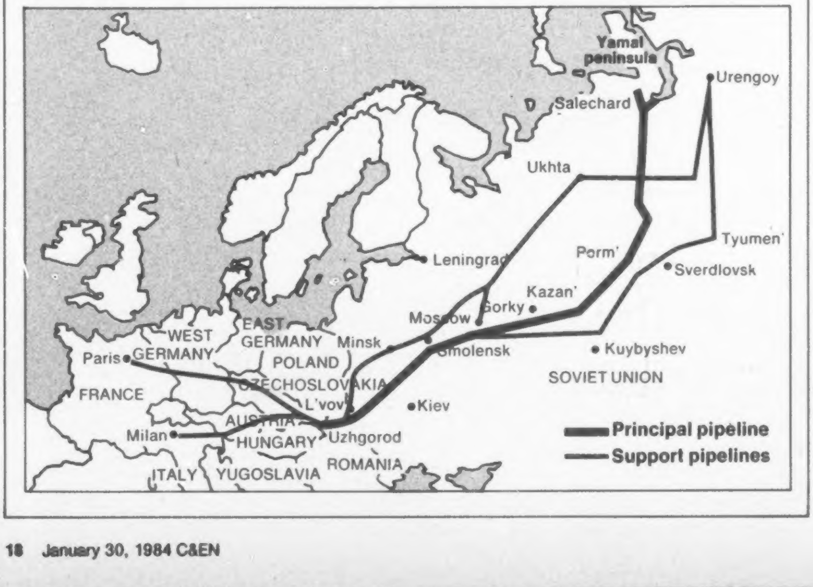
The pipeline itself has been the focus of world attention since it first was proposed some years ago. If, as is being said, the line is in operation, it represents a significant technical achievement. Portions of its 3600-mile length traverse difficult terrain. Through it will flow gas destined also for Austria, West Germany, Italy, and Switzerland.

West Europeans view the Siberian deposit as another source of gas to supplement supplies from the Middle East, North Africa, the Netherlands, and the North Sea. The U.S., on the other hand, has voiced concern that the gas could become a pawn in the chess game of international politics. West European dependency on the Soviets for significant quantities of gas, the U.S. argues, provides the Soviets, if they so wished, with some considerable leverage over Europe's economies.

Considering the charges and countercharges that have crisscrossed the Atlantic on the issue, it may be understandable to overlook the fact that Soviet natural gas has been piped to Western Europe for a number of years. According to figures compiled by the Paris-based International Energy Agency, Soviet gas already accounted for 70% of Austria's overall gas consumption in 1982. West Germany, Italy, and Switzerland, too, are dependent on gas from the U.S.S.R. to varying degrees. IEA doesn't have a breakdown for France, which isn't a member of the agency.

There is no doubt that use is set to increase. IEA projects that Austria's reliance on Soviet gas, for instance, could rise to 80% of its 1990 gas requirements.

Soviet pipeline to bring natural gas from Siberia to Europe



Projections of gas use point to increased dependency on U.S.S.R.

Millions of metric tons of oil equivalent	Total gas consumption	Gas imported from U.S.S.R.	% of total
Austria			
1982	3.7	2.6	70%
1990	4.5	3.6	80
West Germany			
1982	38.0	6.5	17
1990	51.0	14.0	27
Italy			
1982	22.1	6.0	27
1990	32.0	12.0[a]	37
Switzerland			
1982	1.1	0.2	18
1990	1.4	0.4	29

[a] Contract for additional Soviet gas imports has been signed, but awaits Italian government approval.

It is reasonable to assume that some of the gas will be used as feedstock by the chemical industry. According to estimates drawn up a few years ago by the European Council of Chemical Manufacturers' Federations (CEFIC), Austria this year was expected to use 465,500 metric tons of oil equivalent of gas for making chemicals, 67% of the 1984 expected total hydrocarbon feedstock requirement. Next in terms of gas needs by the chemical industry are Switzerland with 59,500 metric tons of oil equivalent, 47% of its total feedstock requirement; Italy with 3 million, nearly 31% of its total; and West Germany with 3.6 million, 15% of its total. CEFIC estimates gas feedstock use by the French chemical industry this year at 3.5 million metric tons of oil equivalent, 24% of its total need.

It's possible, of course, that these projections won't prove accurate in absolute terms. But the figures might be taken to provide an order of magnitude of the role of gas, and possibly of Soviet gas, as a chemical feedstock in these countries relative to alternate liquid and solid hydrocarbons.

Dermot O'Sullivan, London

EPA Probes Groundwater Pollution Threat

Groundwater contamination is a growing problem in the U.S. It has led to the closing of public and private wells in at least 25 states. One of the possible major sources of groundwater contamination is surface impoundments used for the storage, treatment, and disposal of liquid wastes. Congress is showing a growing interest in regulating these facilities, and the Environmental Protection Agency has just published the National Surface Impoundment Assessment Report.

The survey, mandated by the Safe Drinking Water Act, was prompted by the knowledge that increased emphasis on air and water pollution controls resulted in an increase in sludge and waste water generation and disposal. But little information was available on the numbers, location, and construction of surface impoundments or their potential for groundwater contamination.

Although the data are old—they were collected between 1979 and 1980—the report does provide the broadest look yet at the use of impoundments and how that use may affect groundwater quality. The EPA survey done in conjunction with the states identified a total of 80,263 sites containing 180,973 impoundments; 31,286 of the sites were subjected to a desk-top analysis to determine their potential to contaminate groundwater.

Of the sites, 31% were associated with oil and gas extraction, commonly known as brine pits; 25% with municipal water and waste treatment facilities; 18% with farming, crop production, and animal husbandry; 15% with processing, storage, or disposal of industrial waste; 9% with ore extraction and washing, crushing, and sorting; and 2% could not be categorized.

Among findings of the survey:

- Nearly 50% of the sites are located over thin or permeable unsaturated zones that are vulnerable to contamination.
- 70% of the industrial impoundments, 78% of the municipal sites, and 84% of the agricultural sites are unlined.
- 35% of the industrial sites contain wastes that may be hazardous, based on their standard industrial classification code.
- Nearly 30% of the sites in the industrial category are unlined and located in areas of thin or very permeable soils with good usable aquifers, with one third of the sites located within 1 mile of a water well that could be affected by contamination.
- Monitoring data show little apparent correlation between the potential for aquifer contamination and use of monitoring wells.

Results of the survey led EPA to conclude that treatment, storage, and disposal of liquids in surface impoundments is common practice and, in general, impoundments have historically been constructed without apparent regard for the protection of groundwater quality and thus have a high potential for contaminating groundwater.

Despite the potential for contamination, there is no single federal law designed to protect groundwater supplies. What protection there is comes from enforcement of a number of other laws, such as those regulating hazardous waste disposal, new chemicals and pesticides, and those providing funds for cleanup of existing contamination problems. And that might be the only way to go; decontaminating groundwater once it is contaminated, even if theoretically possible, would be horribly expensive. Prevention may be the only solution.

Nine industries account for 80% of 25,000 located impoundments

Industry	Located sites	Located impoundments	Assessed sites
Food	2087	4960	1608
Chemicals and allied products	1414	4377	1176
Stone, clay, and glass products	698	1243	580
Petroleum and allied products	671	1884	537
Fabricated metals	661	1316	513
Primary metals	574	1380	444
Power plants	543	1671	442
Lumber and wood products	348	781	294
Oil field services	266	764	97

The House recently approved an amendment to the Resource Conservation & Recovery Act that would establish a national commission to study groundwater problems and report to Congress, within two years, on recommendations for groundwater protection legislation. In addition, the bill would ban land disposal of bulk or noncontainerized liquid hazardous wastes; prohibit land disposal of six specific liquid waste streams, primarily those containing cyanide or heavy metals; and require operators of surface impoundments to install liners and leachate collection systems. Similar amendments have been approved by the Senate Committee on Environment & Public Works and are now awaiting floor action.

The Energy & Commerce Committee is considering amendments to the Safe Drinking Water Act, H.R. 3200, that would prohibit underground injection of hazardous waste near drinking water aquifers and provide states with money to identify groundwater sources and begin planning for their protection and use.

No drinking water legislation has yet been introduced in the Senate, but the Environment & Public Works Committee will be taking a close look at the issue in a series of hearings early this year. And EPA is planning a followup study to assess the current state regulatory programs and to define the problem in greater depth.

Janice Long, Washington

FEBRUARY 13, 1984

CHEMICAL & ENGINEERING

NEWS

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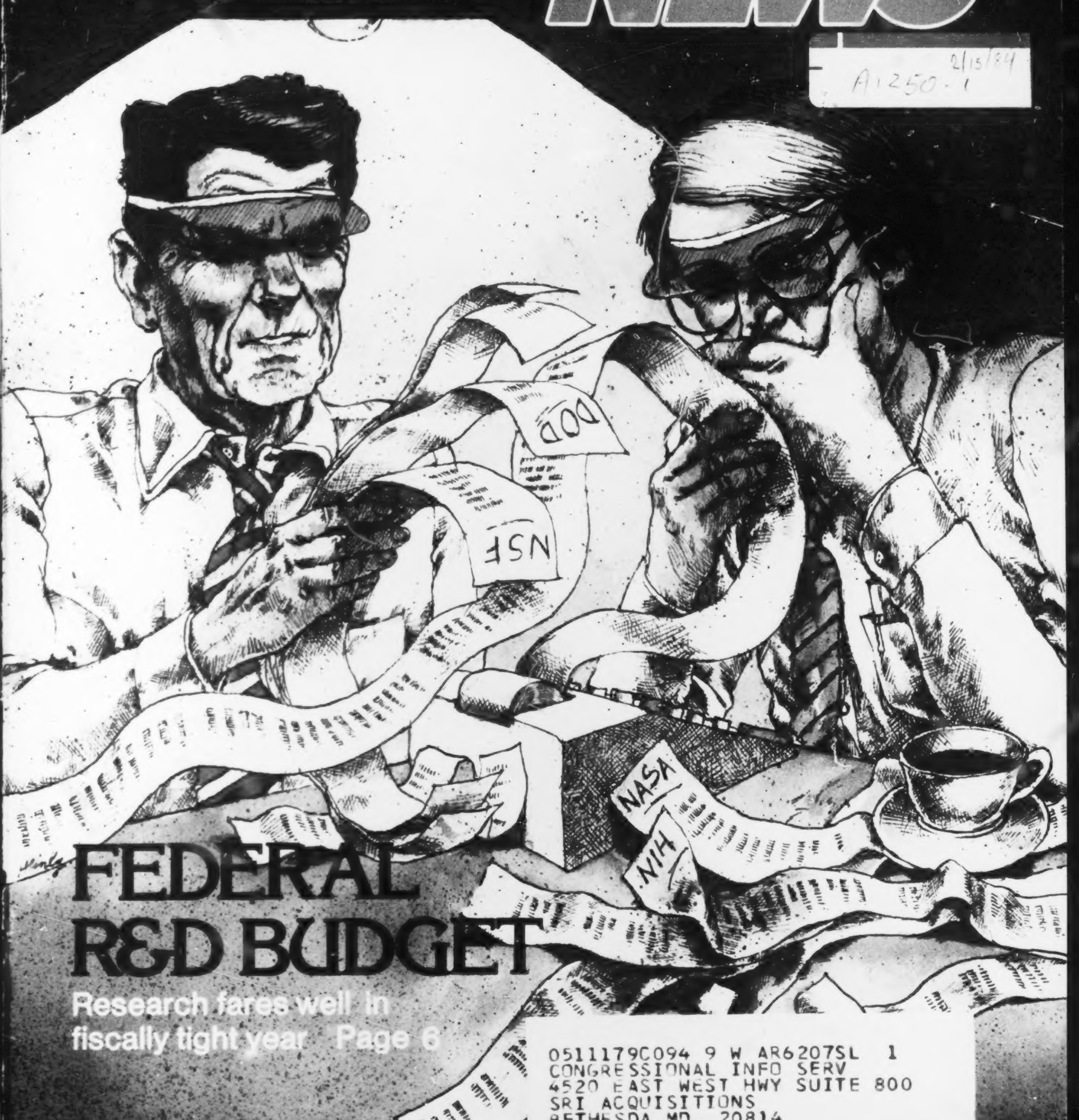

FEDERAL R&D BUDGET

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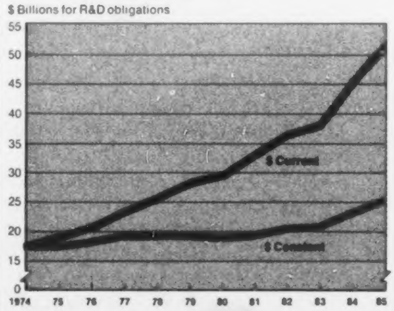


Proposed budget would boost R&D funds 9% in constant-dollar terms . . .

News Focus

President's proposed 1985 budget raises R&D funds 14%; defense gets 96% of increase. Page 6

R&D Funding Will Rise 14% In 1985 Federal Budget

Defense accounts for nearly 96% of $6.5 billion hike in R&D obligations; R&D funding requests for most of the departments and agencies are up

Janice R. Long, Lois R. Ember, and David J. Hanson
C&EN Washington

In his annual budget message to Congress, President Reagan characterized basic research as "a critical investment in the nation's future." Basic research, he said, "lays the foundation for a strong defense in the years to come and for new technologies and industries that will maintain U.S. industrial leadership, create new jobs, and improve our quality of life."

The fiscal 1985 budget proposal that accompanied that message bears out his words. Total obligations—money committed—for basic research are scheduled to rise 10% from 1984 to $7.9 billion. Outlays—money actually spent—will increase 11% to $7.5 billion. If these proposals are accepted by Congress, the two-year (1983-85) growth in federally supported basic research will total 24%.

Obligations for total R&D are up even more in the proposed budget, rising 14% from 1984 to $51.8 billion, resulting in a two-year increase of 35%. Outlays also are slated to be up 14% to $48.7 billion, a two-year increase of 33%. That's not bad in the context of a total federal budget in which outlays, at $940.3 billion, are only 8% more than in 1984 and 16% more than in 1983. (Revenues are estimated to be $745.1 billion, leaving a deficit of $195.2 billion.)

In general, proposed funding for R&D activities in fiscal 1985 continues the trend of recent years, with defense projects eating up nearly 96% of the $6.5 billion increase in federal R&D obligations. But for five of the 13 major federal departments and agencies that support R&D activities, funding requests are down from 1984, according to figures from the Office of Management & Budget.

With this emphasis on defense, it's not surprising that the Department of Defense remains the giant among the R&D-supporting agencies. With its 1985 total research, development, testing, and evaluation budget slated for $34.0 billion, including R&D facilities,

Glossary of budget terms

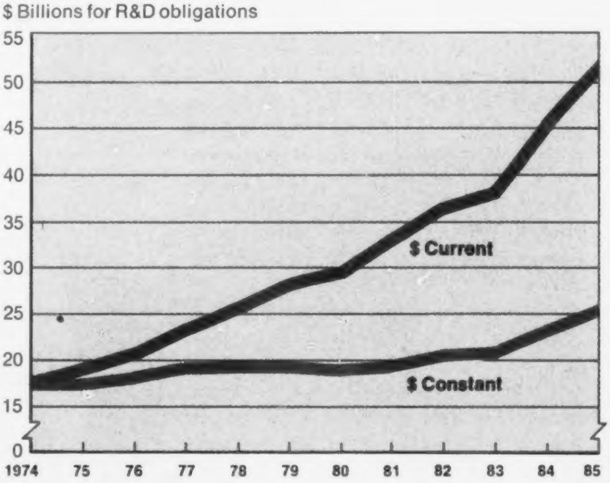
Fiscal year. Year running from Oct. 1 to Sept. 30. The fiscal year is designated by the calendar year in which it ends.

Obligations. Commitments made by federal agencies to pay out money for products, services, or other purposes, as distinct from the actual payments.

Outlays. Payments for obligations incurred under budget authority, generally made by issuance of checks by the Treasury. Outlays during any fiscal year may be for obligations incurred in prior fiscal years or in the same fiscal year.

Note. The R&D numbers obtained from individual agencies frequently differ from those used by the Office of Management & Budget in preparing its analysis of total federal R&D funding.

Proposed budget would boost R&D funds 9% in constant-dollar terms . . .



the department will account for 65% of total federal R&D spending, about the same percentage as in 1984. The 1985 figure is 26% more than 1984 obligations and includes a 15% increase for basic research to $939 million.

Most of the Defense funds are scheduled for development and testing of large strategic and tactical weapons systems. The largest of these include work on the Trident II missile system, funded at almost $2.1 billion, up 38% from 1984; evaluation of the Peacekeeper (MX) missile at $1.7 billion, down 13%; and continuing development work on the B-1B bomber at $508 million, down about 31%.

There is some significant growth in the Defense Department's basic research, but almost all of it is for development of technologies for sensors, high-velocity missiles, and directed energy systems that will be needed for an antiballistic missile system. This so-called "Star Wars" technology has led to a 123% increase in research on advanced technology development, to $3.0 billion in the 1985 budget.

As was the case in approving the 1984 budget, the enormous Defense RDT&E budget proposed for 1985 probably will become a prime target for Congressional budget cutters. DOD had about $2 billion chopped from its 1984 budget request, and with so much concern in Congress about the rising defense budget, the record R&D figures proposed for 1985 will be tempting targets. The advanced technology budget request for 1984, for instance, was cut more than 50%, so it can be expected that the huge increase requested by the President once again will be cut significantly. The budgets for major weapons systems also likely will be cut, probably as much as a billion dollars each, but the basic technology research base will remain intact.

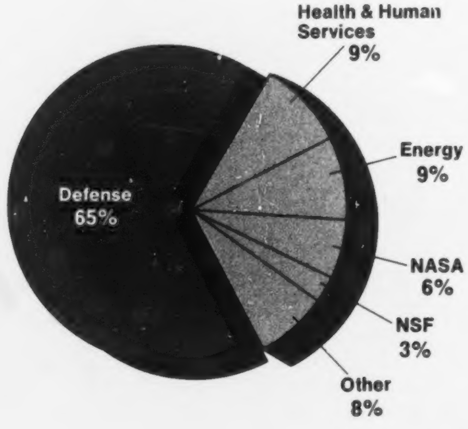
The Department of Health & Human Services again will be the second largest federal supplier of R&D funds, but its renewed eminence is not due to large Administration budget requests. The National Institutes of Health comprise more than 90% of the total R&D performed in HHS, a level that has been constant over the past several years. And, since the coming of the Reagan Administration, NIH budget increases have been very small. The $91 million increase requested in the 1985 NIH budget is just 2%, the third straight year of requested increases that are less than the rate of inflation. However, Congress, as the Administration well knows, has a habit of being quite generous where NIH is concerned.

None of the NIH institutes actually would receive a reduction in funds (there is a drop in construction of new facilities), but all are slated to grow such a small amount that NIH is going to have difficulty keeping its number of grants at the 1984 level. In her presentation of the department's budget, HHS Secretary Margaret M. Heckler said NIH would fund 17,000 research projects and awards in 1985, an increase of 5% over 1984. How that will be done on such a small increase is not detailed. Two areas of research singled out for special emphasis, however, are Alzheimer's disease and Acquired Immune Deficiency Syndrome.

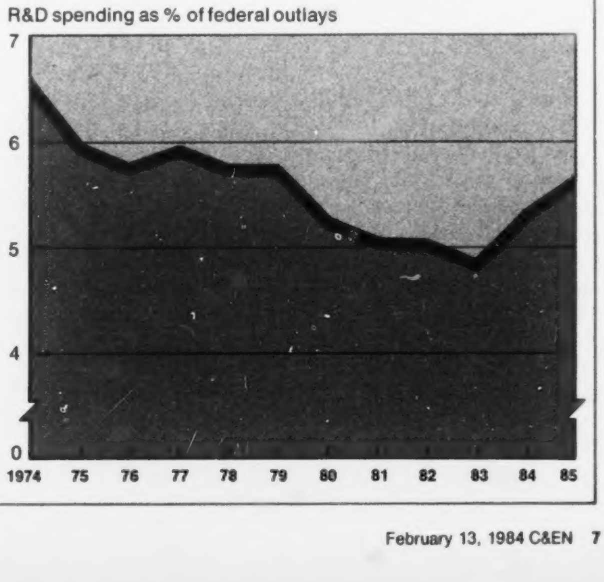
Other HHS agencies conducting research get similar small increases in the budget proposal. The Centers for Disease Control, which include the National Institute for Occupational Safety & Health, however, are slated for a small cut in occupation-related research. The Alcohol, Drug Abuse & Mental Health Administration is funded at $355 million, up $9 million from 1984. And the Food & Drug Administration's R&D on food and drug products would get a $2 million boost to $81 million. FDA, incidentally, has been without an administrator since September 1983.

The Department of Energy has slipped into third place as a supplier of R&D funds for 1985, but there seems to have been a turnaround in attitude toward research. For 1985, instead of asking for substantially

. . . with the Department of Defense getting the largest share . . .



. . . and total R&D funding accounting for more than 5% of federal outlays



less R&D funding, it is requesting an increase of 8% to $4.9 billion. Even when the 22% ($314 million) increase for weapons R&D and testing is excluded, there remains a $61.2 million, or 2%, increase for DOE's civilian R&D programs. When this is contrasted with the 1984 budget request, which asked for an 11% cut in civilian R&D, the change of heart is evident.

Part of this shift, too, owes to Congress' refusal to go along with the requested cuts. As Energy Secretary Donald P. Hodel puts it, "We have come a long way in our discussion with Congress over how to provide a balanced and mixed energy system. I think we're getting there [in terms of] the series of technologies we are pursuing from the R&D standpoint." As an example of this progress, he says that whereas the department requested $70 million for conservation R&D in 1984, it is now requesting $148 million for 1985, only $3 million less than Congress actually appropriated for 1984.

Other DOE programs slated for declines are nuclear fission R&D, down 8% to $618.1 million (primarily because Congress axed the Clinch River breeder reactor); solar and other renewables, down 11% to $191.3 million; fossil energy R&D, down 17% to $272.9 million; and electric energy systems and storage, down 20% to $35.3 million. However, increases are scheduled for research on magnetic fusion, up 3% to $483.1 million; environmental research, up 4% to $228.2 million; and general science and research, up 16% to $746.1 million.

The big winner in DOE's budget request, aside from defense R&D, is supporting research and technical analyses, which is up 21% to $479.6 million. Within that category, support for basic energy sciences is up 24% to $419.5 million, with funding for chemical sciences up 9% to $89.7 million.

Overall, says Elliot Pierce, the chemical sciences division's director, chemistry didn't fare badly, considering the budget pressures. New facilities, such as the national synchrotron light source and the combustion research facility, will continue to be brought on stream and continuing emphasis will be placed on such research areas as photochemistry, coal chemistry, combustion, catalysis, and separation and chemical analyses. Operating expenses for materials science research are up 13% to $141.5 million. About half of the increase will go for actual research, the rest for major facilities operations.

At the National Aeronautics & Space Administration, a revival in activity is occurring, although not necessarily one accompanied by a revival of the large funding increases of the agency's heyday in the early 1960s. The total fiscal 1985 request for NASA is just under $7.5 billion, which NASA Administrator James M. Beggs says is about 4% higher than the current 1984 plan. As in the current fiscal year, large chunks of NASA's budget are being moved out of R&D and put into the general categories of program management and space flight operations and communications.

Still, even with most of its money diverted to ongoing projects related to the space shuttle, NASA lists a

THE TOTAL FEDERAL R&D BUDGET PROPOSAL

Total R&D funds would rise 14%

	Obligations			Outlays		
$ Millions	1985ª	1984ª	1983ᵇ	1985ª	1984ª	1983ᵇ
Defense	$33,852	$27,636	$22,925	$31,053	$25,310	$21,057
HHS	4,950	4,859	4,348	4,869	4,529	4,092
Energy	4,885	4,844	4,491	4,744	4,853	4,771
NASA	3,341	3,257	2,570	3,314	3,462	2,538
NSF	1,408	1,239	1,062	1,362	1,136	992
Agriculture	898	872	846	880	866	832
Transportation	498	519	360	481	445	280
Interior	363	415	374	368	403	403
EPA	281	250	241	277	252	312
Commerce	272	357	327	276	349	324
Agency for International Development	264	225	177	297	298	235
Veterans Administration	198	223	164	208	174	154
Nuclear Regulatory Commission	168	191	207	167	211	229
Other	396	393	338	416	399	340
TOTAL	**$51,774**	**$45,280**	**$38,430**	**$48,712**	**$42,687**	**$36,559**

a Estimate. b Actual. **Source:** Office of Management & Budget

Funds for basic research would rise 10%

	Obligations			Outlays		
$ Millions	1985ª	1984ª	1983ᵇ	1985ª	1984ª	1983ᵇ
HHS	$2914	$2783	$2473	$2800	$2591	$2319
NSF	1330	1173	1000	1288	1072	932
Energy	1230	1039	912	1134	1010	904
Defense	939	815	784	875	787	722
NASA	828	714	615	786	638	594
Agriculture	420	387	362	397	387	355
Interior	97	120	87	101	115	100
Smithsonian Institution	66	60	54	64	58	54
EPA	26	23	22	18	22	30
Commerce	18	21	19	19	19	19
Veterans Administration	15	15	14	15	15	14
Education	14	11	13	16	19	14
Other	29	31	28	35	37	28
TOTAL	**$7926**	**$7192**	**$6383**	**$7548**	**$6770**	**$6085**

a Estimate. b Actual. **Source:** Office of Management & Budget

Funds for R&D facilities would fall 9%

	Obligations			Outlays		
$ Millions	1985ª	1984ª	1983ᵇ	1985ª	1984ª	1983ᵇ
Energy	$ 661	$ 630	$ 576	$ 690	$ 606	$ 627
Defense	369	446	308	367	333	263
NASA	171	185	125	163	139	108
Agriculture	28	61	34	39	41	33
NSF	18	9	3	16	8	3
HHS	15	58	48	43	33	27
Other	45	49	43	49	37	27
TOTAL	**$1307**	**$1438**	**$1137**	**$1367**	**$1197**	**$1088**

a Estimate. b Actual. **Source:** Office of Management & Budget

1985 R&D budget of $2.4 billion, and an additional $939 million for R&D management. The biggest news in the budget is the $150 million that will go to starting design of a permanently manned space station. NASA predicts the effort will require $8 billion to complete by sometime in the early 1990s. The space station is expected to expand the commercial uses of space, and NASA is inviting other nations and private companies to finance such ventures for the future.

Continuing major R&D programs include work on the space telescope and development of an upper atmosphere research satellite. Large increases are slated for space shuttle payload development, up 30% to $105.4 million. The development of the gamma ray observatory is taking off as well, with a healthy 39% boost to $120.2 million. And the Venus radar mapper mission is almost out of sight with a proposed rise of more than 200% to $92.5 million.

A few new, small R&D projects also are funded in the 1985 budget. These include $1 million for interdisciplinary research, $3 million for tethered satellite payloads, $15 million for work on a scatterometer (to measure wind patterns across the oceans), and $16 million for startup work on the Mars geoscience/climatology orbiter.

The Administration's emphasis on basic research can easily be discerned in the National Science Foundation's total budget, which projects a 14% increase to $1.5 billion, including a 15% increase in research activities to $1.3 billion. The budgets for all but one of NSF's activities would be up; science and engineering education's budget is being held essentially constant at $75.7 million.

According to NSF director Edward A. Knapp, the agency has enough money to get its new science education initiative started, and it now needs to see what kind of proposals it will be getting in this area and how ongoing pilot programs work out.

Research instrumentation continues to be emphasized in the new budget request, with a 20.3% increase from 1984 to $237 million. About $122 million would support instrumentation for individual research projects, with the remainder going to support intrumentation at multiuser centers at universities and national centers. Support for research equipment and instrumentation by the directorate of mathematical and physical sciences is up 20% in the new budget to $99 million.

Student support is also a key point in the 1985 budget. The stipend for NSF graduate fellows will be raised from $8100 to $9000 per year, and the number of fellows will increase by 550 to 1550. The number of graduate students supported by research projects is expected to grow 1050, or 10%, to 11,614; total dollar support will increase 15% to $103.4 million. Support by the mathematical and physical sciences directorate is slated to rise 17% to $42.1 million, with the number of students up 496 to 4985. Support for postdoctoral research will increase 12% to $57.7 million. Support for research at predominately undergraduate institutions will increase 15% to $42.4 million.

One new initiative in the budget, supported at $10 million, is establishment of centers for cross-disciplinary research in engineering to do work in areas such as computer-integrated manufacturing systems, voice and data communication systems, and biotechnology processing systems. Another new, $500,000 initiative is research opportunities for women, which is aimed at allowing not only women wanting to re-enter the research area but those who have not yet had an opportunity to be principal investigators, to do independent research.

Research funding at the Department of Agriculture has been increasing slowly in recent years but has not been able to keep up with inflation. The 1985 budget request is just over 2% higher than the 1984 funding level, and, although some programs are up, much of the increase is wiped out by a 6% cut in research for the Forest Service.

The major research office at USDA is the Agricultural Research Service, which is the in-house research agency. With a requested 1.7% increase over the current fiscal year, significant research support will be provided for improving animal and plant genetics to resist disease, the biological control of pests, and soil fertility. Nearly $90 million has been requested for processing and storage research, some of which is likely to go to finding alternatives for fumigating stored food after the currently used pesticide, ethylene dibromide, has been banned.

The Cooperative State Research Service is slated for a 7.7% increase over current-year levels, with much of the rise slated for competitive research grants in animal science and biotechnology. This $33 million increase counters cuts of $11 million in special research grants and $5.8 million in livestock and poultry disease research. There is also another $3.5 million added to support research at the state agricultural experiment stations, the 1890 colleges, and Tuskegee Institute.

The Forest Service, the other major USDA research agency, is concerned primarily with timber sales and reforestation. Its research function is cut to $103 million in 1985. This cut of more than $6 million from 1984 would mean several labs would have to be closed and many low-priority research projects discontinued. USDA estimates that more than 100 positions would be eliminated.

The Department of Interior's R&D request for 1985 is estimated at $363 million, down $52 million from the current fiscal year. Budget documents say the decrease "reflects reductions in activities more appropriately supported by the private sector or states."

Nearly 90% of Interior's research budget is consumed by the Geological Survey, $148 million; the Fish & Wildlife Service, $111 million; and the Bureau of Mines, $69 million. Only the Fish & Wildlife Service's R&D efforts would get increased support in 1985, and the $5 million boost is slated for state fish and wildlife agencies and for acid rain research, which will be supported at a level of about $21 million.

Among the research efforts still retained by Interior are studies to improve the scientific basis for evaluating water resources, including the effects of underground waste storage (Geological Survey); to develop

HOW THE AGENCIES FARE

Research at NASA to increase 14%

$ Millions	1985[a]	1984[a]	1983[b]
Conduct of R&D	**$2390.6**	**$2019.2**	**$1955.5**
Physics and astronomy	677.2	567.6	470.3
Space transportation systems	361.4	431.7	415.5
Space applications	344.1	291.0	347.7
Aeronautical research	342.4	302.3	280.0
Planetary exploration	286.9	217.4	186.4
Space station	150.0	—	—
Space research & technology	150.0	137.0	124.6
Life sciences	63.3	58.0	55.7
Tracking and data acquisition	15.3	14.2	13.4
Research program management	**939.0**	**861.0**	**759.0**
R&D facilities	**171.0**	**185.0**	**125.0**
TOTAL	**$3500.6**	**$3065.2**	**$2839.5**

a Estimate. b Actual. **Note:** Obligations. **Sources:** National Aeronautics & Space Administration, Office of Management & Budget

EPA's R&D effort on the rise again

$ Millions	1985[a]	1984[a]	1983[b]
Air	$ 65.2	$ 62.3	$ 60.0
Energy	48.5	30.4	26.7
Hazardous waste	34.8	32.3	33.4
Toxic substances	27.1	24.4	26.8
Water quality	26.8	24.8	31.6
Drinking water	23.1	23.8	21.8
Interdisciplinary	20.4	21.3	9.8
Superfund	12.7	8.8	6.9
Program management	9.3	8.5	8.9
Pesticides	8.0	6.3	6.1
Radiation	2.1	1.8	1.5
TOTAL	**$278.0**	**$244.7**	**$233.5**

a Estimate. b Actual. **Note:** Obligations. **Source:** Environmental Protection Agency

USDA research would be up, but barely

$ Millions	1985[a]	1984[a]	1983[b]
Agricultural Research Service	$485.0	$476.7	$463.0
Cooperative State Research Service	266.8	247.7	244.9
Forest Service research	103.1	109.4	107.7
National Agricultural Library	11.7	10.4	9.1
TOTAL	**$866.6**	**$844.2**	**$824.7**

a Estimates. b Actual. **Note:** Obligations. **Source:** Department of Agriculture

DOD to receive giant increase

$ Millions	1985[a]	1984[a]	1983[b]
Tactical programs	$10,510	$ 7,909	$ 7,255
Strategic programs	8,714	7,843	5,825
Intelligence & communications	4,216	3,404	2,708
Defensewide mission support	3,877	3,284	2,975
Advanced technology development	3,442	1,386	823
Technology base	3,226	3,042	3,238
TOTAL	**$33,985**	**$26,868**	**$22,824**

a Estimates. b Actual. **Note:** Obligations. **Source:** Office of Management & Budget

Research at DOE would rise 8%

$ Millions	1985[a]	1984[a]	1983[a]
Energy supply R&D	**$2035.6**	**$2019.5**	**$2125.9**
Nuclear fission	618.1	674.7	814.0
Magnetic fusion	483.1	470.8	458.1
Supporting research and technical analysis	479.6	395.1	333.0
Environmental research	228.2	219.3	217.0
All other	226.6	259.6	303.8
Defense R&D, testing	**1723.2**	**1409.3**	**1184.8**
General science and research	**746.1**	**641.3**	**569.0**
Fossil R&D	**272.9**	**329.6**	**311.0**
Conservation R&D	**148.0**	**150.9**	**135.0**
TOTAL	**$4925.8**	**$4550.6**	**$4325.7**

a Estimate. **Note:** Obligations. **Source:** Department of Energy

NIH R&D request is essentially static

$ Millions	1985[a]	1984[a]	1983[b]
National Institutes	**$4219.6**	**$4120.8**	**$3705.8**
Cancer	1101.1	1077.3	987.6
Heart, Lung & Blood	718.9	703.2	624.3
Arthritis, Diabetes & Digestive & Kidney Disease	475.3	462.6	413.5
General Medical Sciences	423.9	415.6	369.8
Neurological & Communicative Disorders & Stroke	344.6	335.2	297.1
Allergy & Infectious Diseases	325.4	314.1	279.1
Child Health & Human Development	280.2	275.2	254.3
Environmental Health Sciences	183.8	179.8	164.9
Eye	157.9	154.7	141.9
Aging	117.4	114.9	94.0
Dental Research	91.1	88.2	79.3
Research resources	**245.7**	**242.6**	**213.9**
National Library of Medicine	**51.3**	**49.6**	**51.9**
Office of the Director	**27.5**	**26.7**	**24.7**
John E. Fogarty Center	**11.4**	**11.3**	**10.1**
Research facilities	**11.1**	**25.0**	**17.5**
TOTAL	**$4566.6**	**$4476.0**	**$4023.5**

a Estimates. b Actual. **Note:** Obligations. **Source:** Office of Management & Budget

NSF budget would be up 14% . . .

$ Millions	1985[a]	1984[a]	1983[b]
Mathematical and physical sciences	$ 416.7	$ 358.8	$ 300.4
Astronomical, atmospheric, Earth, and ocean sciences	373.5	330.0	280.8
Biological, behavioral, and social sciences	253.1	224.6	191.2
Engineering	147.1	120.7	101.1
Antarctic program	115.1	102.5	83.2
Science and engineering education	75.7	75.0	16.1
Program development and management	70.9	66.6	65.7
Scientific, technological, and international affairs	46.9	40.8	44.1
Special foreign currency	2.8	2.9	2.2
TOTAL	**$1501.8**	**$1321.9**	**$1084.8**

a Estimate. b Actual. **Note:** Obligations. **Source:** National Science Foundation

. . . with funding for sciences up 11% . . .

$ Millions	1985[a]	1984[a]	1983[b]	% change 1984–85
Ocean sciences	$ 124.9	$113.7	$102.5	10%
Physics	121.8	105.9	89.2	15
Physiology, cellular and molecular biology	116.4	102.1	87.3	14
Materials research	113.0	97.5	81.1	16
Atmospheric sciences	98.6	89.3	75.5	10
Astronomical sciences	93.4	78.2	62.7	19
Chemistry	92.1	80.0	67.6	15
Biotic systems and resources	59.9	53.4	46.0	12
Mathematical sciences	50.5	41.5	34.8	22
Earth sciences	48.6	41.5	34.9	17
Behavioral, neural sciences	42.2	38.5	34.0	10
Computer research	39.3	33.9	29.3	16
Chemical and process engineering	32.5	26.6	22.6	22
Social, economic sciences	28.0	24.6	20.3	14
TOTAL	**$1021.9**	**$922.7**	**$767.5**	**11%**

a Estimate. b Actual. **Note:** Obligations. **Source:** National Science Foundation

. . . and chemistry up 15%

$ Millions	1985[a]	1984[b]	1983[a]	% change 1984–85
Chemistry	**$ 92.1**	**$ 80.0**	**$ 67.4**	**15%**
Chemical dynamics	16.9	14.5	13.6	16
Structural chemistry and thermodynamics	15.5	13.6	12.9	14
Chemical physics	14.8	13.1	10.6	13
Chemical instrumentation	13.5	11.6	7.8	16
Synthetic organic, natural products chemistry	11.3	9.7	6.3	18
Chemical analysis	11.0	9.6	7.1	15
Synthetic inorganic, organometallic chemistry	9.1	7.9	7.1	15
Chemical and process engineering	**32.4**	**26.6**	**22.4**	**22**
Chemical, biochemical processes	7.2	5.7	4.5	26
Kinetics, catalysis, and reaction engineering	5.6	4.5	3.5	24
Thermodynamics and transport phenomena	4.9	4.1	3.9	19
Particulate, multiphase processes	4.5	3.9	3.2	15
Engineering energetics	4.2	3.8	3.5	10
Separation processes	3.4	2.2	1.7	54
Minerals, primary materials processing	2.6	2.4	2.1	8
Biochemistry	**14.6**	**12.8**	**11.4**	**14**
Marine chemistry	**13.4**	**12.0**	**10.8**	**12**
Solid-state chemistry	**9.0**	**7.7**	**6.5**	**17**
Polymers	**7.6**	**6.4**	**5.5**	**19**
Atmospheric chemistry	**7.2**	**6.7**	**5.6**	**7**
Experimental, theoretical geochemistry	**6.1**	**5.7**	**4.9**	**7**
Volcanology and mantle geochemistry	**3.9**	**3.6**	**2.6**	**8**
TOTAL	**$186.3**	**$161.5**	**$137.1**	**15%**

a Estimate. b Actual. **Note:** Obligations. **Source:** National Science Foundation

domestic sources for strategic and critical minerals now being imported (Bureau of Mines); and to develop cloud seeding techniques to generate additional water supplies (other department programs).

The Department of Commerce's research efforts also would be cut back an estimated $85 million to $272 million. Research support by the National Oceanic & Atmospheric Administration is slated to be cut 31% to $167 million. Termination is scheduled for the undersea research program and the Sea Grant program, and substantial decreases are in store for ocean mineral activities and ocean and Great Lakes research and services.

Compared to NOAA research, the National Bureau of Standards must be quite happy with what it says is a 9% increase to $126.1 million. Funding for measurement research and standards will be up 14% to $58.8 million, and funding for the technical competence fund up 6% to $8.7 million. However, the Administration wants to cut the funding for computer sciences and technology in half and completely do away with the fire research program—moves it tried to make for 1984 only to be beaten back by Congress.

After three years of rather drastic cuts to the Environmental Protection Agency's research budget—cuts that Congress repeatedly has attempted to restore—the Reagan Administration has reversed itself. For 1985, the Administration has requested a 14% increase in R&D funds to $278 million, but that is still $25 million less than the amount spent in fiscal 1981.

EPA Administrator William D. Ruckelshaus says the agency's research program will be strengthened in four major areas: acid rain, risk assessment, control technology, and human health hazards. With a 124% boost to the acid rain/energy research ledger, mainly to study causes, effects, and mitigation strategies, this endeavor garners the greatest share of the scheduled 14% overall increase. But also receiving significant funding is research to understand and control hazardous and toxic chemicals in air, water, and land.

The Administration also is requesting an increase of $4.4 million to improve its risk assessment ability. Special emphasis will be placed on estimating the effects of pollutants on human health. EPA's new integrated cancer assessment program will generate data to relate air pollution to cancer, for instance.

Though the growth in environmental R&D funds is welcomed after three years of strangulation budgets, the hefty increase slated for acid rain research is viewed with mixed feelings. Environmental groups, several members of Congress, and Canadians all recognize the need for more study to fill in knowledge gaps, and they applaud the additional funds. But they also view the increase as a sop that allows the Administration to wiggle off the hook of controversial acid rain control programs.

Congress still has to work its will on the fiscal 1985 budget. Changes will be made. But except in the area of defense R&D, any changes in funding are likely to be upward rather than downward. At least that has been the practice in recent years, and it is unlikely to change in an election year. □

Chemical Firms Lured by Their Own Stock

"The company believes that the acquisition of [its] shares at this time is an attractive investment." This is part of a news release late last year announcing that National Distillers' board of directors had authorized the repurchase of up to 3 million of its own shares in the open market or through private transactions.

In the past six months, a number of chemical producers have chosen to repurchase their own stock. Reasons vary from company to company, but generally fall into a well-defined pattern for industry as a whole.

In general, companies repurchase shares to cover employee stock purchase and bonus plans rather than increasing the number of shares outstanding by creating new shares. Issuing new shares would dilute earnings per share and lower the book value of the company. In fact, the very act of repurchasing can raise earnings per share, and at times companies will repurchase stock just for this purpose. Covering of stock plans is the principal reason for the majority of repurchasing schemes, according to a study last year by the Conference Board, a business research group in New York City.

Other companies, such as National Distillers, will invest cash in their own securities. This is especially true of companies with temporary cash surpluses. By buying their own shares, dividends go to the corporate treasury, and, in effect, the company is retaining the dividend on that stock. Another way of looking at it is that the company is earning a cash return on its investment equal to the dividend rate paid on the stock outstanding. In addition, it would gain any increase in the stock price in a rising stock market.

Also, another group of chemical companies that have repurchased stock in the past six months are trying to get rid of high-overhead odd-lot (small-lot) holdings by shareholders. When the stock is held in small quantities by a large number of stockholders, the cost of servicing those accounts is a very heavy burden to corporations. Thus, at various times companies will buy back the odd lots from stockholders. Usually odd lots are defined as fewer than 100 shares.

Another strategy in firms' repurchasing shares is to support the market value of their stock. However, according to the Conference Board study, there is some doubt as to the ability of large corporations with large numbers of shares outstanding to buy back enough shares to make much of a difference in the stock price. Further, the study says, some executives believe that it would be illegal to engage in this practice.

Though stock repurchasing plans are expected to flourish, they by no means will be uniform in their pace. Like any prudent investor, companies tend to try to buy their stock when the market price is low. Thus some companies will allocate a certain amount of money for stock repurchases rather than announce the number of shares they will buy. A prime example of this is Sun Co., which announced earlier this year a $100 million stock repurchase program to take place throughout 1984. However, Sun has not said how many shares it will try to acquire. At current market prices, this would represent almost 2 million shares. However, if prices come down, look for Sun to start buying more heavily.

William Storck, New York

Size of and reasons for repurchase vary widely

Company	Number of shares	Value[a]	Remarks
Allied	5 million	$275 million	Also repurchased 2.9 million of 3 million previously authorized shares
Ashland Oil	35,000	$35 million[b]	Private transaction
Beatrice Foods	10 million	$340 million	Company also repurchased 105,531 odd-lot shares
Dow Chemical	2 million	$68 million	Purchased to cover shares issued to employees through stock option and purchase plans
Engelhard	150,000	$5.7 million	To provide shares for delivery under stock bonus and option plans. May repurchase 100,000 more
Gulf Oil	421,564	$18.5 million	Repurchased odd lots of 99 shares or fewer
Eli Lilly	3 million	$195 million	Repurchased for stock plans and corporate purposes
National Distillers	3 million	$81 million	Company called itself "an attractive investment"
Olin	600,000[c]	$18.4 million	Odd lots of 99 shares or fewer
Sun Co.	d	$100 million	Already has repurchased 11.5 million shares. Purchases will be used for strategic corporate purposes or held as treasury shares

a Approximate value at time of announcement. b Face value. c Approximate number of odd-lot shares outstanding. d Number of shares repurchased will depend on market price.

Chemistry Faculties Gain Women Slowly

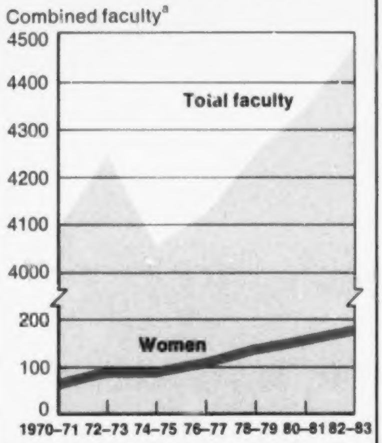
Male dominance of Ph.D.-granting chemistry faculties in the U.S. is still almost absolute. But it is not quite so absolute as it was.

According to the latest in a series of six biennial surveys conducted for the American Chemical Society's Women Chemists Committee, such faculties were 95.9% male during the 1982–83 academic year. This was down from 98.5% recorded for the 1970–71 academic year in the first survey.

Over this 12-year span the total number of women on such staffs increased from 61, out of 4091, to 180, out of 4470. All the surveys include only full-time staff members holding the rank of assistant professor, associate professor, or professor. They exclude research associates and other staff members not in the tenure track.

Although the total number of women still remains remarkably modest, there has been a sharp decrease in the number of all-male faculties—from 74% of the total in 1970–71 to 44% in 1982–83. Over the same period the number of faculties with three or more women has grown from four to 14. The number with just one woman has moved from 33 to 61.

Women make up only 4% of chemistry faculties



a Of all Ph.D.-granting chemistry departments. **Source:** Report compiled for ACS Women Chemists Committee

A parallel analysis of the faculties of biochemistry departments offering graduate studies indicates that women have a somewhat stonger foothold on such staffs. But it also reveals that this foothold has not grown lately. It actually slipped slightly from 8.6% in 1976–77 to 8.5% in 1982–83. In 1982–83, 23% of the 136 departments surveyed had no women on their faculties.

This latest survey was compiled by Sister Agnes Ann Green, former professor of chemistry at Immaculate Heart College, Los Angeles, using data from 1983 College Chemistry Faculties published by ACS. She also conducted the five previous surveys. For these she used the ACS Directory of Graduate Research.

Green's data seem to indicate that women still are not joining chemistry faculties in numbers proportional to the rate at which they are earning chemistry Ph.Ds. If a 4% attrition rate is assumed for faculty members, it appears that in recent years about 7% of those joining the ranks of chemical academia have been women. In these same years women have made up about 14% of chemistry Ph.D. graduating classes.

The faculty of American University, Washington, D.C., had the highest proportion of women in 1982–83—four out of 10. The faculty with the highest number of women, eight out of 27, was that of the colleges associated with the University of Massachusetts. This faculty also shows the largest gain for women over the 12 years covered by the surveys—from one to eight. The University of Illinois, Chicago, went from one to six over this period, with all of the gain actually coming between 1980–81 and 1982–83. And two schools show gains of four women since 1970–71—the University of Lowell and the University of California, San Diego. They both went from zero to four.

Ohio State University had the largest remaining all-male chemistry faculty, 37, in 1982–83. It was followed closely by the University of Washington, 35, and Iowa State University, 33. The largest all-male biochemistry department, 22, was at the University of Texas, Galveston. □

These faculties have at least three women . . .

School[a]	Faculty[b]	
	Total	Women
U of Massachusetts, Amherst and Boston	35	3
U of Massachusetts, associated colleges	27	8
U of Illinois, Chicago	36	6
Rutgers U	41	6
U of Puerto Rico	31	5
American U	10	4
U of California, San Diego	41	4
City U of New York	84	4
U of Lowell	25	4
U of Maryland	46	4
Portland State U	22	4
Boston U	21	3
U of Idaho	14	3
Polytechnic Institute of New York	22	3

. . . but these larger faculties are still all male

School[a]	Total faculty[b]
Ohio State U	37
U of Washington	35
Iowa State U	33
State U of New York, Stony Brook	31
Oregon State U	30
U of Chicago	29
U of Cincinnati	29
Virginia Polytechnic Institute	29
Georgia Institute of Technology	28
Northwestern U	28
U of Pittsburgh	28
U of Utah	28
U of California, Santa Barbara	27
U of Oklahoma	27
U of Arkansas	26
Auburn U	25
Notre Dame U	25
U of Virginia	25

a Ph.D.-granting schools only. b 1982–83 academic year.

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chemical sales and earnings
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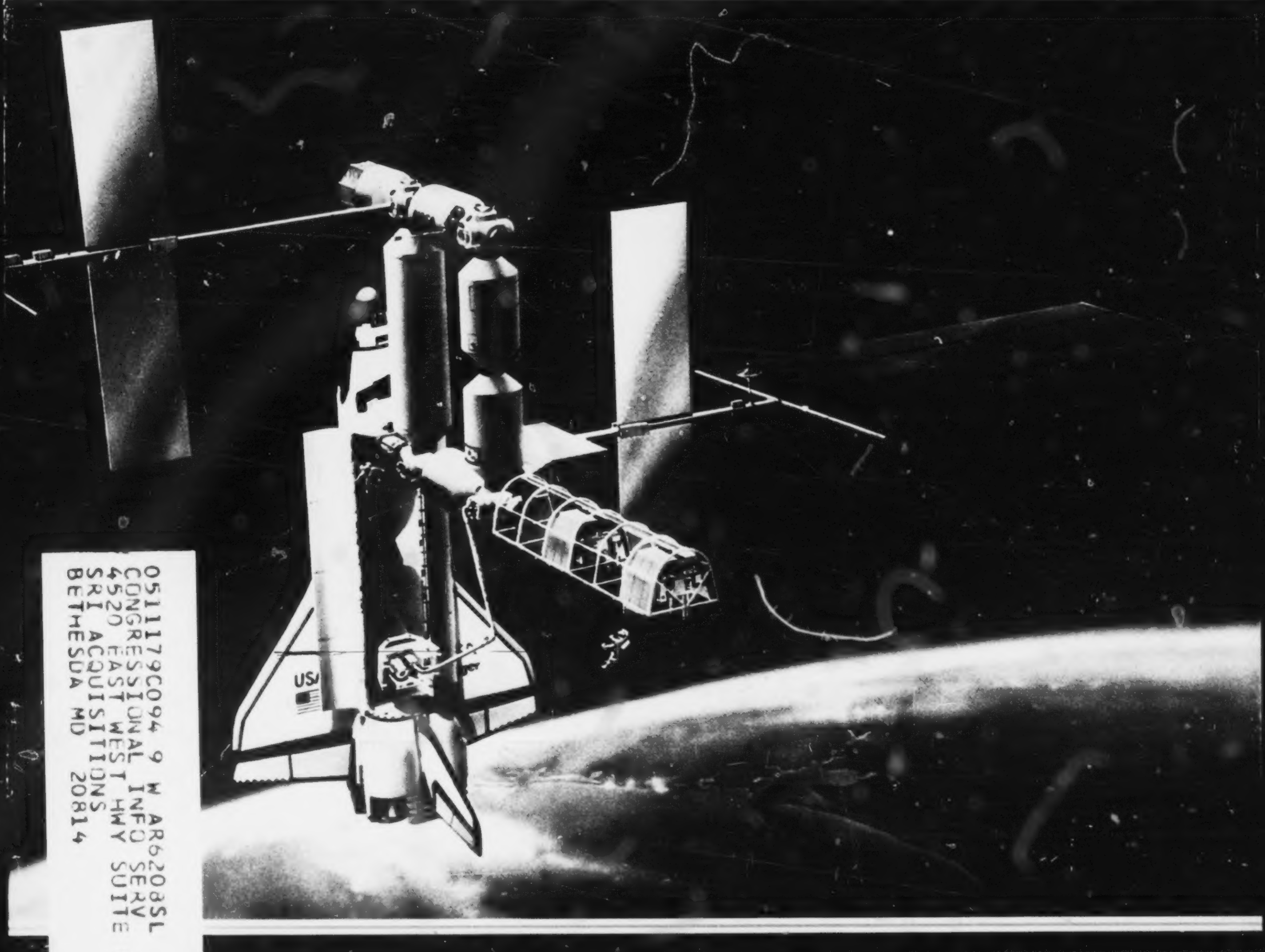

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SPACE POLICY

New era starts with space station Page 9

Cover: Artist's conception of
future space station. Photo
courtesy of NASA

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CHEMICAL & ENGINEERING NEWS

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- **Second viral oncogene/growth-factor protein link found.** **Page 7**
- **Patent approval of Stanford's recombinant-DNA technology products appears likely.** **Page 7**
- **Harvard biochemist Matthew Meselson wins $256,000 MacArthur Foundation award.** **Page 7**
- **EPA revises national ambient air quality standards on particulate matter.** **Page 8**
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Business

Near doubling of chemical industry earnings in fourth-quarter 1983 pushed up year's figures 6% over 1982 earnings. **Page 18**

International Business

Worldwide sales of man-made fibers are expected to continue to improve this year; strong fourth quarter put three of the four major Canadian chemical companies in the black. **Page 24**

Government

Reversing past trends, Administration's 1985 budget gives EPA 8% hike in funding, smaller increases to other regulatory agencies; EPA will regulate 25 hydrocarbon wastes as a group. **Page 29**

Science

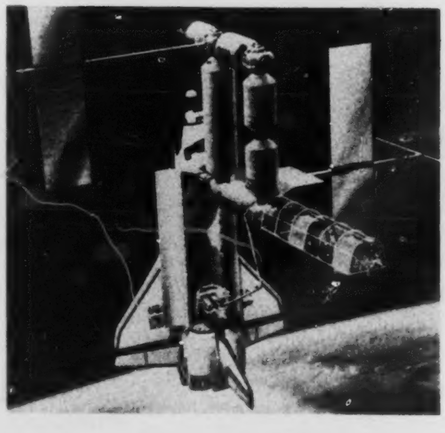
New infrared spectroscopy technique gives high resolution of gas-phase molecular ions without neutral ion interference. **Page 34**

Technology

Process to convert tetraborate ores to flame retardant ammonium pentaborate is less expensive than current method; polyethylene fiber, developed by DSM, said to be stronger than carbon and steel fibers but low melting point is drawback. **Page 36**

Books

Two books relating attempts to resolve question of authenticity of the Shroud of Turin reach opposite conclusions. **Page 38**



News Focus

Space station goal marks beginning of new era, but some fear Star Trek will become Star Wars. Page 9

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LETTERS

Kudo to Dick Moore

SIR: Richard L. Moore's "Comment" in C&EN, Dec. 19, 1983, page 51, deserves a serious reading by every member of the American Chemical Society.

Moore gives well-deserved credit to others for contributions they have made in behalf of ACS public relations. I have observed his very effective personal efforts in behalf of the society's public relations efforts. ACS as well as all chemists and chemical engineers enjoys a better rapport with the public at large thanks, in part at least, to Dick Moore.

This "kudo" is to make note of the professional job he has done as an outstanding chemist member of ACS and the public relations community.

O. A. Battista
World Olympiads of Knowledge, Fort Worth

Experimenting with truth

SIR: I was surprised but very gratified by Wil Lepkowski's review (C&EN, Jan. 16, page 63) of my book "Experimenting with Truth"—for two reasons. First, his review itself was in the nature of the very dialogue I seek to engender within our scientific communities of the largest questions and issues of existence. Second, because he spotted the obvious incompleteness of this one book as a statement of life-policy (a word I substitute for "faith"). I hope to fill in those blanks with my personal statements soon.

In the meantime, however, I would like to call the attention of those readers who are interested in contemporary statements about "meaning" to two brilliant and sparkling books with surprising insights: "The Faces of Science" (and also "Realms of the Unconscious") by Soviet mathematician V. V. Nalimov, ISI Press, 1981, and "To An Unknown God" by Petru Dumitriu, Seabury, 1982. These are poetic and profound works about profound subjects written in a linguistic metaphor and style which professional scientists, whether positivists, agnostics, Hindu, Jewish, or Christian, can all immediately understand.

Rustum Roy, *Director*
Materials Research Laboratory
Pennsylvania State University

SIR: I haven't read the book yet, but I was intrigued by Wil Lepkowski's review of "Experimenting with Truth" by Rustum Roy.

If there are scientist readers of this review who feel that their lives need further moral underpinnings, but who have no impression of the existence of gods, God, or even Rustum Roy's "***," I would suggest that they investigate the American Humanist Association. Its main tenet is that there are no "beings" or "essences" watching over us, any more than "they" watch over other earthly fauna or flora. A corollary tenet is that to achieve a more loving, helpful, rewarding, civilized human life, we need but follow the "golden rule," which was expressed by Confucius over 2500 years ago.

Richard M. Lemmon, *Berkeley, Calif.*

SIR: Wil Lepkowski's review of "Experimenting with Truth" by Rustum Roy was excellent. While commending Roy's objective of bringing about dialogue between agnostic scientists and theists, he has succinctly exposed the contradiction between Roy's beliefs and basic Christianity.

I applaud C&EN for publishing this review so that the Christian message was presented in an uncompromising way.

William J. Schell
Separex Corp., Anaheim, Calif.

Corrections

- Jan. 23, page 31: The correct name of the liquid heavy-duty detergent being marketed in the U.K. by Stridebond is Cool Force, not Cold Force.
- Jan. 23 page 32: The table of Western European producers of fatty alcohols (detergent-range) should include Albright & Wilson, with a capacity of 25,000 metric tons per year, and the correct figure for Henkel is 170,000 metric tons. Total nameplate capacity is 397,000 metric tons, and demand 215,000 metric tons per year.
- Jan. 23, page 34: The patent situation regarding detergent zeolites was incompletely described. Henkel has patents on the use of zeolites as detergent builders in most countries, and is still trying to obtain patent coverage in the U.S. It has granted application licenses to Colgate-Palmolive, Procter & Gamble, and Unilever, to other detergent makers in Germany, to producers in France and Switzerland, and to detergent producers in Japan, including top producers Kao Soap and Lion Corp. Henkel also has teamed up with Degussa, with both companies pooling their respective patents on composition of matter and process, to form the 50-50 joint venture company Sasil-Patent Verwertungsgesellschaft. This company has issued process licenses to various companies around the world. Akzo, as well as U.S. producers Ethyl, W. R. Grace, PQ, and Union Carbide, has its own production processes.

U.S. Space Policy Ready for Next Big Leap

The big goal is now set—a space station in 10 years—and shuttle missions with science payloads abound in 1984; big question remains extent of military involvement

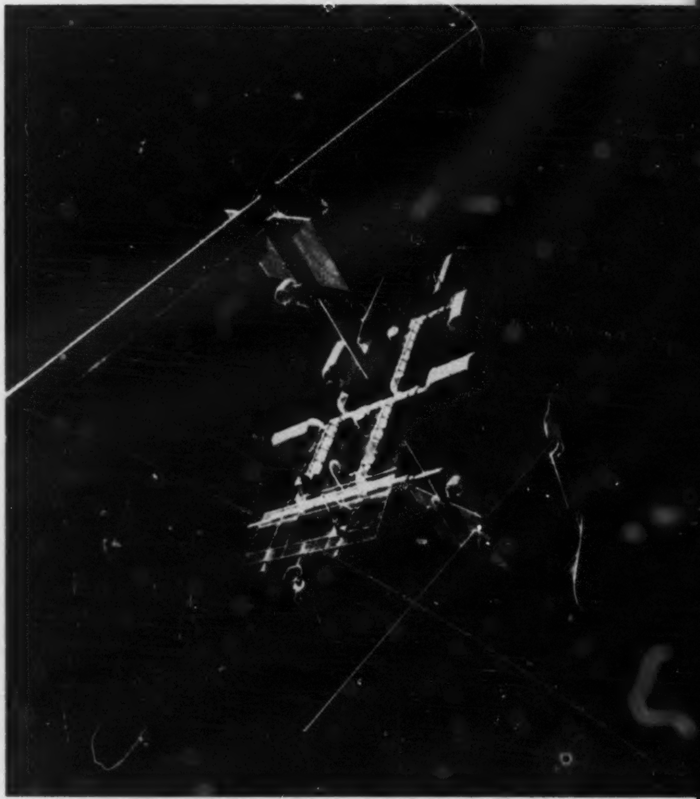
Wil Lepkowski, C&EN Washington

These are days of high rejoicing within the U.S.'s 450,000-member aerospace community. The National Aeronautics & Space Administration, now a mite over a quarter-century old, will begin developing its long-cherished space station, once Congress approves the $150 million the Administration is asking. The usefulness of NASA's space shuttle is established beyond any doubts. And the space altruists now feel the stage is set for some real pioneering again.

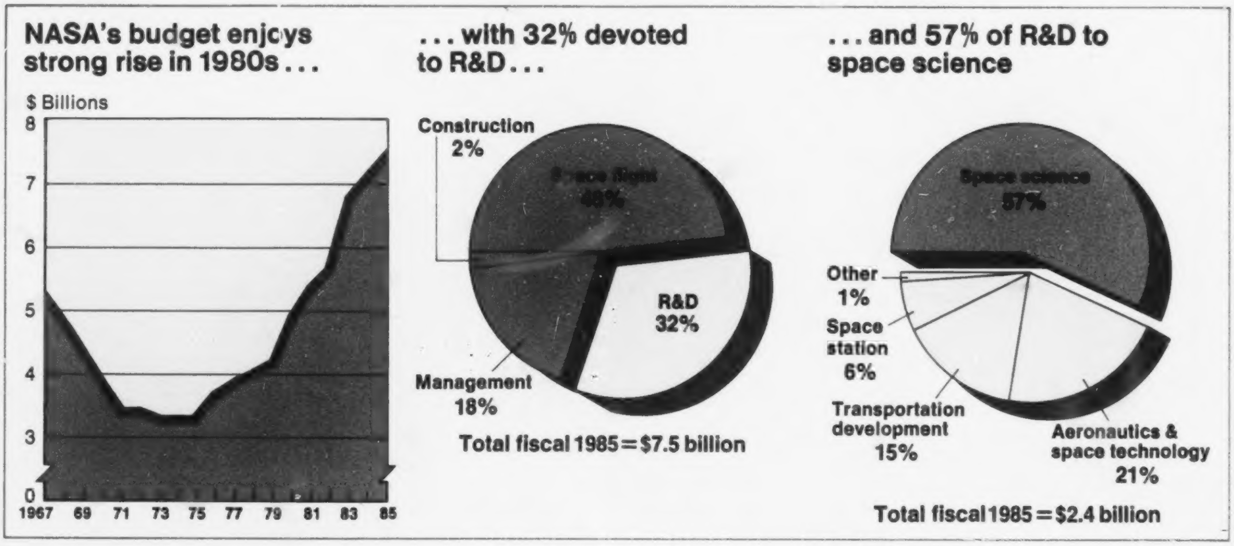
At the same time, the aerospace and weapons community also is celebrating. The military budget for space activities passed NASA's last year, and it's said that more than $30 billion will be spent by the Pentagon on laser and particle beam weaponry alone through fiscal 1989. Much of it will be placed on the ground but will require space-based hardware for the complete systems to work.

So as space becomes militarized, grand dreams and grim cold war realities face public discussion and Congressional debate as a new era in space opens. Within all this is the vast internationalization of space with its accompanying sets of stresses, strains, and promises. Will space be monopolized by the superpowers? Is the U.S. lead in profit-making space technology being threatened by Europe and Japan? Should not space be seen as "commons" where cooperation and not competition rule the day? Must the countries of Earth take their deadly squabbles into that commons?

Big questions. Big issues. Meanwhile, NASA's menu of launchings for 1984 is its busiest in history. Ten shuttle missions are scheduled, along with 12 unmanned scientific payloads. Two dozen communications satellites are going up, plus two Earth resource satellites and one weather satellite. The rest are secret military payloads and scientific experiments that will be aboard the shuttle. The European Space Agency, Japan, and India, too, are looking ahead to busy years. And everyone knows, of course, that the Soviet Union is going to be more than active.



"The world of space technology is now very different from what it was in the 1960s and even late 1970s," declares John Logsdon, who follows space policy closely as director of the graduate program in science and technology policy at George Washington University. "The players are different, and the issues


NASA's budget enjoys strong rise in 1980s . . .

. . . with 32% devoted to R&D . . .

. . . and 57% of R&D to space science

Total fiscal 1985 = $7.5 billion

Total fiscal 1985 = $2.4 billion

are different. What went on during those times did not have a very strong linkage to economics and security. But increasingly there is that link now to core values in society. We tend to think of space activities as a unity. But in fact they make a diverse variety. The Trekkies of a few years ago are today's entrepreneurs," Logsdon says.

All this is to say that satellites, like any of mankind's inventions, can be peacekeepers or war makers. The spacecraft operated by the Central Intelligence Agency and the Air Force are so sensitive to the electromagnetic commands generated at Soviet missile sites, that the President could have as much as a three-day warning of Soviet missile firings. Satellites today are the crux of any global command and control system. They see, they hear, and they tell, and more and more international firms are seeing them that way, too.

Space is where mankind's ambitions fuse optimally with mankind's technology. At NASA the latest manifestation of that fusion is the space station and the agency's plans to involve private venture capital and corporate investment in it as much as possible.

"The space station," declares NASA Administrator James M. Beggs, "provides a logical stepstone approach to the exploration and exploitation of space. We are entering an era when commercialization of space will become truly important."

Right now, commercialization is established only in the field of satellite technology. But the list of noncommunications companies with ambitious hopes and plans is growing. The companies bear names like Eros Data, Astrospace, Ecosystems International, Fedex Spacetran, Orbital Systems, and Spacewatch. They join older line companies like Du Pont, Aluminum Co. of America, Honeywell, Eli Lilly, 3M, and Johnson & Johnson in exploring all manner of research on materials development and processing. And so it goes. The commercial and economic phase is here, incipient, loaded with skeptics, but attracting investment capital.

NASA was scheduled this month to make public its study of space commercialization policy. Commercialization policy will be a bit muddied for a while because politics and cost make private investment chancy. Only in communications technology has industry become well established and almost self-sufficient in space. In short, the Administration is groping for a working space commercialization policy.

Two years ago, Congress' Office of Technology Assessment said in a report that "there is no overall agreement about the direction or scope the civilian space program should assume in the future." The report said that the lack of agreement on "appropriate goals" was making it difficult for the executive agencies to set specific timetables for developing space systems that meet user needs, to encourage private sector investment, and to initiate new and/or implement mandated programs. In addition, the report said the Reagan Administration had general ideas but "no clear and predictable ways" of defining the transfer of NASA's research, development, and demonstration programs to the private sector. OTA says it sees no reason to change the report's conclusions.

Early last year, the government announced plans to sell its weather satellites to the private sector. A public and Congressional uproar put an end, if temporarily, to that plan. But the Administration, following an earlier Presidential executive order, has put out for bids its sale of NASA's land resource satellites. The Commerce Department, handling the bids, will be announcing qualifiers in a month or so. If no bids are acceptable, NASA will continue with development of resource satellites on its own.

But the sale of such public service satellites as weather and remote sensing craft presents so many economic, political, international, and management problems that critics complain that NASA and the government have not really thought things through. This is what makes space so complicated and probably too involved to expect that there can be anything like a comprehensive space policy.

Said Arnold Frutkin, assistant to the international group president at Burroughs Corp., in the September 1983 issue of *Spectrum* (a publication of the Institute of Electrical & Electronic Engineers): "President Reagan's recent notion to turn weather and Earth survey satellites over to the private sector, when it is widely recognized that there is no commercial viability for such systems without government subsidy, threatens the hard-won precedents of international public service developed over decades. Lighthouses might, by a considerable stretch of the imagination, be run for profit by private companies, but something would be lost to the world if they were."

Adds David Williamson, space analyst at Georgetown University's Center for International & Strategic Studies, "A single private entity to own and operate all civil U.S. remote sensing systems would create an effective monopoly potentially dangerous to technical progress and to the economic and social interests of the users." He also says too much financial subsidy would be needed at this stage of technology. Maybe the best alternative, he believes, would be a government/private sector venture chartered by Congress.

But international competition presses on the U.S. efforts, and many feel the Administration will have to put a coordinated effort forward soon. "Without a strategy to guide them," says David W. Lippy, president of the Center for Space Policy of Cambridge, Mass., a consultant firm specializing in helping firms develop space-related ventures, "American companies will lose their competitive edge to companies abroad.

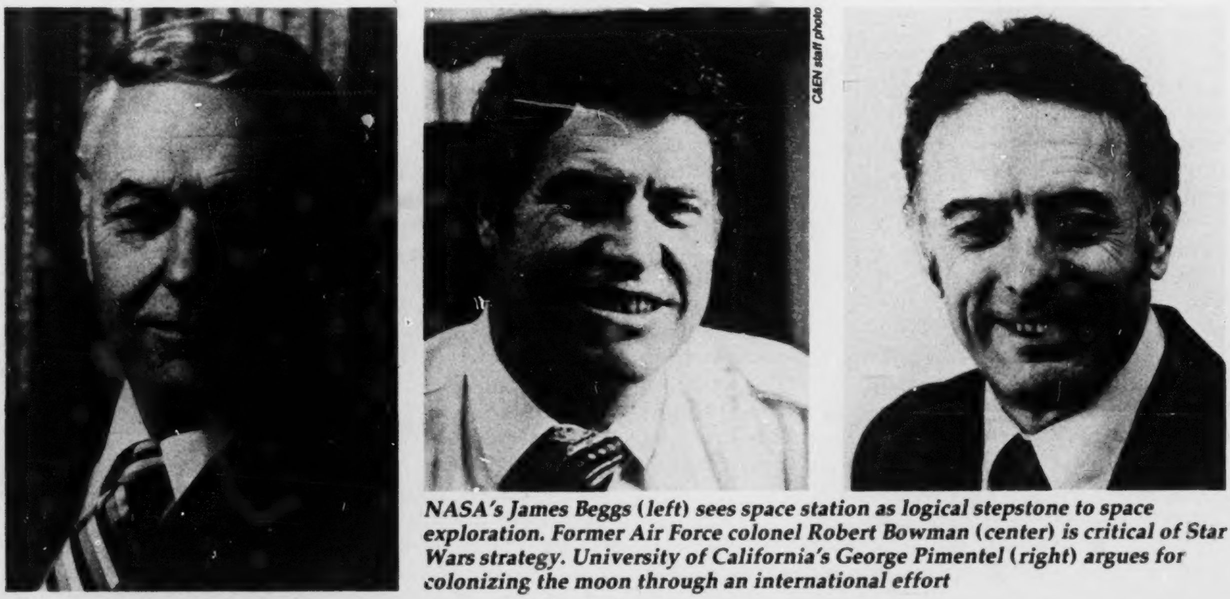
"Arianespace, a European consortium, is marketing the launch vehicle Ariane, a successful competitor to the U.S. shuttle. (Ariane is not a shuttle but a so-called expendable launch vehicle that drops to sea once it releases its payload.) In 1984, another European concern, Spot Image, will market remote sensing packages that surpass the capabilities of the American Landsat system. These companies are only the first trickle in a flood of foreign competition, not all of which are in the aerospace industry."

The Administration lacks an overall commercialization policy, but it does seem to be developing separate policies, sector by sector. NASA, for example, is planning to turn over its Atlas/Centaur rocket launching systems to General Dynamics Corp., the firm that has been building them for NASA since the 1960s. Last month, the agency chose Transpace Carriers Inc., Greenbelt, Md., to take over from NASA the marketing of another expendable launch vehicle, the Delta rocket. Delta is NASA's workhorse for lifting middleweight scientific and communications satellites into orbit.

Another possibility is on-orbit services, or special satellites that would be supply stations and even manufacturing facilities for the various special satellites being launched. The West German firm Messerschmitt-Boilkow-Blohm (MBB) developed a Shuttle Pallet Satellite, called SPAS, and last June Fairchild Industries announced plans to build and launch a Leasecraft platform that would provide a base for as many orbital utilities the platform would have room for. One of the first Leasecraft lessees could be NASA's extreme ultraviolet telescope scheduled for deployment in 1987. It would be placed on the Fairchild craft by the space shuttle. Leasecraft's costs are expected to be about $200 million and would come from private venture capital sources.

SPAS, however, seems to be ahead of Fairchild in its scheduling. MBB has joined with the experienced Comsat Corp. and a venture capital firm. Their initial instrument will be a remote sensing device that will compete with Landsat and the French SPOT system. The SPAS initial investment is about $75 million.

In any case, space entrepreneurship really does seem



C&EN staff photo

NASA's James Beggs (left) sees space station as logical stepstone to space exploration. Former Air Force colonel Robert Bowman (center) is critical of Star Wars strategy. University of California's George Pimentel (right) argues for colonizing the moon through an international effort

The space station—a primer on the next big goal of the U.S. space program

What is the space station?

It is an outpost in space, a potential way station toward colonizing the moon, the beginning, if you will, of a space city. It's a modest beginning, of course, since in 10 years it would contain besides crew quarters and a command module, only a laboratory for zero-gravity experiments, an astronomical observatory, a facility for making materials under zero gravity, and room for attaching instruments for studying Earth and its atmosphere. It also would be a base from which to repair satellites in orbit. It would be built piece by piece from materials transported aloft by the space shuttle. It would have a crew of about 10 and cost a total of about $8 billion. Its life span would be 15 to 20 years.

Why is the space station such a big deal?

The space station is a boost to NASA's goal of being a pioneering agency, and to the space enthusiasts who foresee factories and cities in space. Indeed, some liken space stations to the frontier forts of America's pioneer days. Forts were shelters for travelers, trading posts, medical centers, battle stations, and bases for expeditions. So would tomorrow's space station function.

What are some objections to the space station?

Skeptics claim that the station is an extravagance and that in combination with the shuttle it deprives basic space science of needed money. However, manned space exploration excites the public and Congress much more than do wholly instrumented projects. As Joel Hinners, director of Goddard Space Flight Center, points out, "There's no better system to integrate information than man."

NASA claims to blunt the argument that the station will rob space science of support. It says space science prospered during the expensive Apollo program. And although there will be no basic science involved in the development and construction of the station, once it is built, there will be no end to opportunities for science. Everyone from materials scientists and biochemists to astronomers will have opportunities to design instruments and experiments to further advance their fields in the weightlessness and clarity of space.

What is an example?

NASA makes a point of emphasizing the powerful potential of the space station for astronomy. It envisages an assembly of permanent observatories, including such instruments as an orbiting, very long baseline interferometer, infrared submillimeter telescope, infrared interferometer, ambient deployable infrared telescope, hundred-meter thinned aperture telescope, and very large space telescope. The instruments could be serviced more easily on a platform in

to be proliferating. The consulting firm Booz-Allen & Hamilton has a $200,000 contract from NASA to identify areas in which companies can profit from space laboratory service—analogous to clinical and materials laboratories at zero gravity. The firm has become a prime source of information for venture capitalists and entrepreneurs to find one another to discuss financing opportunities.

As Booz-Allen's Peter M. Stark explains, early profits in materials experimentation in space will derive from a privately owned space laboratory probably aboard NASA's space station. It will be financed, as one might expect, by a group of investment firms and will make its profits by selling laboratory services to customers wishing to have experiments done in zero gravity. The design of such a multipurpose laboratory would mean big opportunities for chemical companies in the laboratory design business, but this one would really be a high-tech affair.

This aspect of commercialization, in contrast to private ownership of utility satellites or development of private space transportation services, has its own set of problems. "What is worrisome," says George Washington University's Logsdon, "is the campaign to create the impression that we soon will see privately owned orbiting factories, private launches bringing valuable products to and from orbit, and a joint public-private space program based on, more than anything, space manufacturing.

"The major obstacles to commercial operations in space are the high cost of space activities and the uncertainties about the feasibility of potential commercial opportunities in areas such as advanced communications, remote sensing, and, particularly, space manufacturing. There is a need for a research program looking into these things."

Logsdon believes space should be sold on several merits, not simply the promise of high-profit commercialization, a phenomenon that could be half a century away.

Thus, a host of unanswered questions and problems remain unanswered. One of the most important issues within all that is squaring this Administration's free market philosophy with international cooperation in commercialization.

What space commercialization competition is showing is that the world is indeed interconnected, especially when U.S., European, and more Japanese investment capital combine to finance the launching of new space ventures. The intercontinental communications cooperative Intelsat, made up of 108 countries, is probably the prototype of international ventures. Although the Soviet Union is not a member, several Eastern European countries, plus China, are.

So, says Georgetown's Williamson, "The rest of the world is going to be heard more and more on international space policy."

Where the two big space superpowers are creating global anxiety is in their plans to militarize space beyond its present role as preserver of global stability. As the world now knows, President Reagan has begun a massive research and development program space than if they were in individual orbits.

Will there be foreign involvement?

At present there are no plans to involve the Soviet Union or the Eastern bloc countries. But NASA says that although no commitments have been made, the European Space Agency, West Germany, France, Italy, Canada, and Japan are all doing studies to establish where they might fit in. NASA Administrator James M. Beggs already is making plans to tour foreign capitals in the spring to explain the station and solicit ideas for cooperation. "We hope they'll spend a lot of money with us and devote a lot of their resources," he says.

Will the space station push the state of the technical arts?

A lot of applied research and technological developments will be needed to develop a successful space station. NASA says generic areas of new technology will include materials and structures, energy conversion, controls, human factors, propulsion, and fluid/thermal systems. The biggest challenges will involve development of an enormous information system monitoring and controlling all elements of the station. Cryogenic fluid management will be a special need, as will be propellant transfer and storage.

How about private sector involvement?

NASA Administrator Beggs says he wants as much private venture capital and activities as possible in station development and operation. What will most likely happen is that companies will make or buy laboratories, or sections of laboratories, then rent them out to other companies. NASA, too, could be a laboratory lessor as well. But space business is expensive, costing up to two orders of magnitude more than doing comparable work on Earth. So the payoff has to be equally high.

To pave the way for the new era of commercialization, NASA plans to assess the kinds of changes that will be needed in tax laws and regulations that it says "discriminate against space ventures."

Beggs believes that private firms will operate their own space stations and transportation vehicles by themselves. "You will have the equivalent of a Federal Aviation Agency, the sort of certification, air worthiness certification, air traffic control, and things of that kind."

Will the military be involved?

According to Beggs: "Our military has to this point stated that they have no requirement to go up. Should they have a requirement, or develop a requirement over time, it would undoubtedly be as a separate activity. That is, they would have their own module, for their own security reasons. This is intended to be a civil program."

leading to systems to defend the territory of the U.S. and its allies from incoming nuclear warheads. Such systems could include laser and particle beam weaponry operating via space to knock out Soviet ICBMs almost immediately after launch. A total defense system could be half a century away, but the Defense Department already is planning to spend at least $26 billion through fiscal 1989 on the program for research, development, and demonstration. On top of that, the Air Force last month conducted the initial test of an antisatellite (ASAT) missile launched from an F-15 fighter.

The Soviets, of course, for a decade have been working with mixed success on an ASAT system of their own. And they are exploring directed energy beam technologies for possible use in ASAT systems and for ballistic missile defense. Robert Cooper, director of the Defense Department's Advanced Research Projects Agency, says, "The Soviets could launch the first prototype of a space-based laser antisatellite weapon in the late 1980s or early 1990s. An operational system capable of attacking other satellites within a few thousand kilometers range could be possible in the 1990s."

But critics say that the militarization of space means that events are set in motion now that disturb the delicate global command, control, and communications system that both sides use to achieve stability, to check one another. The so-called Star Wars development poses conceptual and legal problems not fully explored by its advocates. In aiming to control the high ground, the superpowers are in effect transporting the animosities that rule on Earth into outer space. Thus, instead of space fulfilling the dream of uniting countries to a single purpose of exploration and human development, space could divide them even more.

The trend, to many who have viewed the space program over the years, is tragic. Says Burroughs Corp.'s Frutkin, "The steady increase in the militarization of space is worrisome. A drift that began principally in President Carter's day, it has been abetted by a conclusion on the part of some senior NASA officials in the past half-dozen years that the very future of NASA programs—laid low by annual budgeting stretchouts—depends upon a new alliance with the Pentagon.

"The policy of deliberate cold war rhetoric may have its rationale in the projection of resolve and readiness to the other side to reduce the chances of miscalculation, but it may just as well provoke miscalculation. And apart from this, it is difficult to discern any coherent national space policy on the current scene."

Has the Star Wars strategy really been carefully thought out? Many say no. One critic is Robert Bowman, a former Air Force colonel who is now head of his own Institute for Space & Security Studies in Potomac, Md. Bowman says antisatellite and anti-ICBM weaponry will destabilize the international security system if allowed to continue. Bowman can claim the right credentials, for his last job in the Air Force was director of advanced space programs development in the Air Force space division. He left the military for private industry in 1978 but by 1982 found he had even less freedom to criticize there than in the service. So he left to form his institute.

His thinking, in a nutshell, goes something like this: Most strategic thinkers in the Air Force believe that the present technological system of maintaining global stability is the optimal setup. It is the latest in high technology and performs at the state of the art. These satellites are always monitoring military activities and both sides have them. They do such things as locate and monitor targets, define order of battle, monitor and assess crisis situations anywhere on Earth, provide geodetic information for ICBM targeting, and constantly map strategic regions around the globe.

In fact, Bowman says, the U.S. system is so good that it would be impossible for the Soviet Union to launch a surprise attack on the U.S. "Our B-52s would be off the ground before anything would hit," he says.

"President Reagan is sincere, but he's been sold a bill of goods. Some of the people who formulated the current policy want Star Wars for one reason: It is a necessary ingredient for first-strike capability. They see stability as us having the overwhelming edge." And with that edge, Bowman adds, the U.S. could then pressure the Soviets to abandon their policies and their political and military occupations of other countries—something futile and dangerous to expect.

"I don't see how the Soviets could see us developing first-strike capability," says a White House official who asked to be unnamed. "That's a long way down the road. And as we gain confidence in something reliable and definable, we should sit down and think about rational ways out of this question.

"I could see a defensive system in space producing a stable world where both sides have deterrence without fear of nuclear annihilation. These defensive systems will be expensive. But what we spend for the defensive systems could be less than the Triad (the current combination of ballistic missiles fired from land sites, submarines, and aircraft). In the political sense, the American people would be much more willing to support defensive systems than offensive systems carrying weapons."

The official thinks that opposition to Reagan's plan comes from those with vested interests in status quo deterrence thinking. That is, many analysts and strategists have devoted their careers to the technology and policy of conventional nuclear deterrence. He believes it is this thinking that produces instability. "Overnight they are asked to give thought to a whole fundamental change in a way of thinking. That's why they were so surprised by it.

"We are frontier people," he adds. "What more worthy goal is there if you want to devote your life to something that promises to eventually do away with nuclear weapons? But you have to increase investment, bring strong management and leadership to the technology associated with this capability. And we have to be sure to develop friends and advisers to allay fears that we aren't going to develop first-strike capability. These are things that lie ahead. We don't have easy answers. The President feels that the payoff is of such enormous potential that it will be worth the time and expense."

The subject is vast in its scope. The point, though, is that space does signify power for both stability and instability. Politics of the future will have to be deft and imaginative, with the concerns of the entire Earth in mind.

"Space technology," says Victor Reis of Science Applications Inc., McLean, Va., "does involve a lot of opinions and does represent frontiers of interaction with the rest of the world," he says. "In fact, I'm trying to sort those things out."

Reis' last job was in space policy for the White House Office of Science & Technology Policy. He was one of those taken by surprise by President Reagan's Star Wars speech of March 23. Up to then, he and science adviser George A. Keyworth II were minimizing the feasibility of the laser, particle beam, and x-ray weaponry. Without warning, Reis was suddenly faced with arguing in favor of something he didn't fully believe in.

Reis sees some idealistic promise in NASA's Earth systems science program and serves on a planning committee for it. That program is a followup to NASA's global habitability program, whose name the White House disliked because of the socialistic implications of the word global. When the Earth systems science program gets started, it will involve other agencies and other countries, including the United Nations Environmental Program, in its goal of studying Earth as a complete system to assess more clearly the threats to it. Even the Soviet Union would be included. Says Reis: "If it's a real good program, and if it is global, how could we not involve the Russians?"

And the globe also includes the developing countries, many of which are an annoyance to the U.S. by their hostility at the United Nations. But developing countries now see space technology as necessary for their economic and social development. And they have a couple of worries in this heavily technological world. The first is that since the technology of the industrial countries is the equivalent of global political and economic power, the developing countries deal in space policy from an empty hand. They have no space agency, they have no space development bank.

They have one political forum, the UN. But that is little help for them in establishing a dialogue with the U.S., because to the U.S. the UN is simply a cabal of countries hostile to the interests of America. Not one of the key subcommittees of the UN's Committee on the Peaceful Uses of Outer Space has a U.S. member.

"We are troubled by being excluded from positions in the UN Outer Space Committee," says Otho Eskin, director of the State Department's office of advanced technology. "We hate to see a committee that has been fruitful become just another arena in which the U.S. gets kicked around. So we are examining our whole participation in the committee. In the meantime, we are not going to be very active in it." This summer the committee will be discussing the new proposed Soviet treaty banning all weapons from space. But Eskin says the U.S. will merely observe the debate,

Space science's uneasy relation to space hardware

Academic space scientists are not entirely happy with NASA's treatment of their many fields, from astrophysics to geochemistry. They complain that fields like planetary exploration all play second fiddle to the shuttle program. Every extra $50 million spent on the shuttle to cover cost overruns or unexpected repair bills means another $50 million lost on committed projects like the space telescope or the Jupiter mission called Galileo. Former NASA chief scientist John Naugle, now a vice president at Fairchild Industries, says the 10- to 15-year time gap between new missions is now too great.

"We cannot maintain our scientific leadership in an emerging active discipline such as x-ray astronomy by flying an Einstein Observatory in 1978 and then waiting 13 years until 1991 to follow up the discoveries with the Advanced X-Ray Astrophysics Facility."

But the maturation of the space shuttle program, growing from three shuttle vehicles today to five within the decade should help because the shuttle will be able to place new satellites into orbit and service existing ones routinely.

This year the shuttle will carry Spacelab aloft again in November for another set of experiments. But only one other new scientific mission will take place, that of the active magnetospheric particle trace explorer in August. Two new initiatives, however, were included in the fiscal 1985 budget, an upper atmospheric research satellite and a Mars geoscience/climatology orbiter, slated for launch in 1990.

Instrumentation development is continuing for what would, for the first time, "make a comprehensive global measurement of the stratosphere," according to NASA Administrator James M. Beggs. "This budget will enable us to begin to develop the upper atmospheric research satellite that will place these instruments in orbit."

NASA's proposed budget for space science in fiscal 1985

	$ Millions
PHYSICS AND ASTRONOMY	**$ 677.2**
Space telescope development	195.0
Gamma ray observatory development	120.2
Shuttle/Spacelab payload development	105.4
Explorer development	51.9
Mission operations, data analysis	109.1
Research and analysis	36.9
Suborbital program	58.7
LIFE SCIENCES	**63.3**
Flight experiments	27.1
Research and analysis	36.2
PLANETARY EXPLORATION	**286.9**
Galileo project development	56.1
Venus radar mapper mission	92.5
International solar polar mission	9.0
Mars orbiter	16.0
Mission operations, data analysis	58.8
Research and analysis	54.5
SPACE APPLICATIONS	**344.1**
Solid Earth observations	
Shuttle/Spacelab payloads	18.1
Geodynamics	29.9
Research and analysis	15.6
Environmental observations	
Upper atmosphere research	31.0
Atmospheric dynamics and radiation research	28.5
Oceanic processes research	19.4
Space physics research	16.7
Shuttle/Spacelab payload development	7.8
Earth radiation budget experiment	8.1
Extended mission operations	29.5
Interdisciplinary research	1.0
Tethered satellite payloads	3.0
Scatterometer	15.0
Upper atmosphere research satellite mission	60.7
Materials processing in space	23.0
Communications	20.6
Information systems	16.2
TOTAL	**$1371.5**

holding that such discussion should take place in the Committee on Disarmament.

Space policy has its international security theme setters, but none has been so dogged over the years as Howard Kurtz, former airline executive and retired Air Force lieutenant colonel who heads War Control Planners in Washington, D.C. Kurtz qualifies for the role as space evangelist.

Kurtz believes that all the two superpowers really are doing is preserving a high-technology arms race, that they continue to escalate it and thus endanger the world through a simple paranoiac need to control power. The monopoly has gone far enough, Kurtz believes, and it is time for an international organization to harness space technology in a campaign for global security.

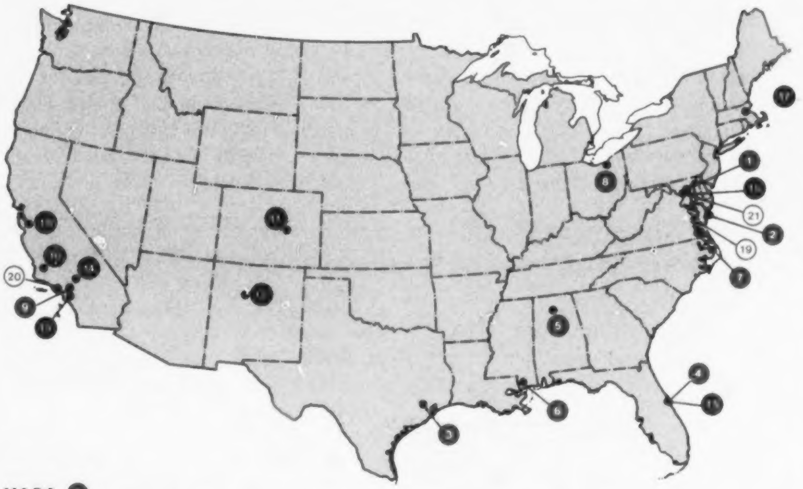
Rep. George E. Brown Jr. (D.-Calif.) is in sympathy with Kurtz but says Kurtz is "25 years ahead of his time." Nevertheless, Kurtz has managed to convince enough people in official positions that the UN has adopted a proposal to establish what is called an International Satellite Monitoring Agency. This agency over the years would not only operate a string of global resource satellites for enhancing social and economic development but form a third security force that through reconnaissance satellites would observe the military activities of the two superpowers.

Kurtz had an ally in the UN's deputy secretary-general Robert Muller, who took the idea to then French Prime Minister Valéry Giscard d'Estaing, who, in turn, proposed it to the UN. Last summer, the UN published a report outlining the technical, legal, and financial implications of the whole idea.

The UN General Assembly is expected to discuss steps—whether by treaty or convention—by which such an agency could come into being. The U.S. and U.S.S.R. have united in opposition to the idea and so it doesn't look like the proposed agency will go anywhere, since neither wants a third power spying on it.

Another space/security theorist is Daniel Deudney of Worldwatch Institute. Worldwatch is one of those

Space effort involves more than 20 major U.S. installations



NASA ❶
1. **Goddard Space Flight Center,** Greenbelt, Md.
2. **Wallops Island Space Flight Facility,** Chincoteague, Va.
3. **Johnson Space Center,** Houston
4. **Kennedy Space Center,** Cape Canaveral, Fla.
5. **Marshall Space Flight Center,** Huntsville, Ala.
6. **National Space Technology Laboratories,** Bay Saint Louis, Miss.
7. **Langley Research Center,** Hampton, Va.
8. **Lewis Research Center,** Cleveland
9. **Jet Propulsion Laboratory,** California Institute of Technology, Pasadena

Air Force ❿
10. **Western Space & Missile Center,** Vandenberg Air Force Base, Calif.
11. **Air Force Space Command & Consolidated Space Operations Center,** Colorado Springs, Colo.
12. **Air Force Space Technology Center,** Kirtland Air Force Base, Albuquerque, N.M.
13. **Air Force Space Division,** Los Angeles
14. **Rocket Propulsion Laboratory,** Edwards Air Force Base, Calif.
15. **Eastern Space & Missile Center,** Cape Canaveral, Fla.
16. **Air Force Systems Command,** Washington, D.C.
17. **Air Force Geophysics Laboratory,** Hanscomb Air Force Base, Bedford, Mass.
18. **Satellite Control Center,** Sunnyvale, Calif.

Navy ⑲
19. **Naval Space Command,** Dahlgren, Va.
20. **Naval Astronautics Group,** Pt. Mugu, Calif.
21. **Naval Telecommunications Command,** Washington, D.C.

whole-Earth think tanks not in very high repute in the Reagan Administration's Washington. Deudney even thinks the industrialization of space is dangerous to global security.

"The first strategy of industrializing near space," wrote Deudney in the recent winter issue of *Foreign Policy*, "has an inescapable military dimension and contains the seeds of planetary tyranny. The difference between civilian function and military capability has always been small in space—and it will all but disappear with the advent of large-scale space ventures such as solar-powered satellites, space colonies, and asteroid mining.

"Solar-powered satellites, first conceived for military purposes, may generate enough power to turn particle-beam and laser systems into viable weapons. And lunar or asteroidal mass accelerators—the slingshotlike devices to turn construction material into orbit that many large-scale space industrialization schemes are based on—have a powerful destructive potential. Such slingshots would make all points on Earth vulnerable.

"Controlling the military potential of these technologies will be virtually impossible if the industrialization of space occurs in an environment of military competition. The fundamental danger of large-scale space ventures rests on one inescapable geopolitical fact: Effective control of outer space means effective control of the planet. Should this high ground be garrisoned or colonized, a high, impregnable castle will have been created."

So much for the strategists. What do chemists have to say? One who offers quick and weighty comments is George C. Pimentel, director of the laboratory of chemical biodynamics at Lawrence Berkeley Laboratory, professor of chemistry at the University of California, Berkeley, and former deputy director of the National Science Foundation. Pimentel is chairman of the National Academy of Sciences' Committee to Survey Opportunities in the Chemical Sciences, whose report is due out later this year. He was involved in space development of the infrared spectroscopy instrumentation for the Mariner 6 and 7 missions to Mars. He also was nearly chosen as a scientist-astronaut.

"I think we have exactly the same debate about to take place today as we had during the 1950s," he says, "when the control of atomic energy was debated, that is, whether society controls its own destiny. I always felt that nuclear power was so important that it had to be under civilian control and the debate kept in the open.

"The issues being argued over with regard to space are even more significant. They are still being argued in terms of the problems of humankind and human conflict. Developments now are moving so fast that we cannot stop them. Great feats in space can be carried out without thought to the ultimate security of the people below.

"So the question is what direction one might go with any chance of reversing the process. The only thing I can see is to leapfrog the whole question of the space station and make a decision to colonize the moon through a wholly international effort. The tangible effect would be to show how we can go ahead and explore space immediately. This would get us into interaction with potential adversaries and change directions in a most favorable way. You grope so hard these days for any ray of hope that promises to diminish rather than increase the adversarial roles of countries." ☐

Chemical Earnings Almost Doubled in Fourth Quarter

William J. Storck, C&EN New York

The fourth quarter was one of surprises for many chemical industry observers. They expected earnings to show a healthy rise over the same period the year before, but what they got exceeded even their wildest expectations.

Earnings for basic chemical companies, instead of rising the 50% or so expected, actually rose 95% over fourth-quarter 1982, according to C&EN's latest survey of major companies. Diversified companies and oil firms that manufacture chemicals also showed earnings rises, but companies whose main business is chemicals were the stellar performers.

In fact, the fourth quarter saved the year for chemical companies, enabling them to show a full-year increase. Earnings had to rise more than 50% in the fourth quarter for the industry to break even for the year. The actual 95% increase pushed up full-year earnings 6% over 1982.

Because of the momentum gained in the fourth quarter by chemical companies, good earnings growth will be a certainty in first-half 1984. Helping the year-to-year comparisons will be weak earnings in first-half 1983.

However, the chemical industry may well have to make its gains mostly on production and operating efficiencies as it did in the second half of 1983. Industry sources say that prices still are not moving up the way that they had hoped. The 2.2% increase in the government's producer price index for chemicals and allied products during the fourth quarter of 1983 is the highest since the second quarter of 1982. And it is only the second year-

Chemical industry leaders for fourth-quarter. . .

Sales			Earnings[a]			Profitability		
Rank	$ Millions	Rank 1982		$ Millions	Rank 1982		Earnings as % of sales	Rank 1982
1 Dow Chemical	$2923.0	1	Dow Chemical	$83.4	15	International Minerals	11.9%	2
2 Union Carbide	2350.0	2	Monsanto	78.0	8	Freeport-McMoRan	11.4	1
3 W. R. Grace	1753.7	3	PPG Industries	67.9	2	Loctite	10.6	5
4 Monsanto	1651.0	4	Union Carbide	58.9	5	Nalco Chemical	10.3	2
5 PPG Industries	963.7	6	W. R. Grace	58.0	1	Morton Thiokol	9.6	4
6 American Cyanamid	923.3	5	American Cyanamid	55.2	3	International Minerals	8.5	8
7 Celanese	850.0	7	Celanese	52.0	30	Air Products	8.2	10
8 National Distillers	706.5	9	Morton Thiokol	44.0	4	Rohm & Haas	7.5	16
9 Hercules	644.0	8	Hercules	42.6	6	Pennwalt	7.3	26
10 Olin	484.9	11	Air Products	34.0	11	Ethyl	7.2	7

. . . and for full-year 1983

Sales			Earnings[a]			Profitability		
Rank	$ Millions	Rank 1982		$ Millions	Rank 1982		Earnings as % of sales	Rank 1982
1 Dow Chemical	$10951.0	1	Monsanto	$388.0	2	International Flavors	14.8%	1
2 Union Carbide	9000.0	2	Dow Chemical	273.0	1	Freeport-McMoRan	11.5	2
3 Monsanto	6299.0	3	Union Carbide	249.1	3	Nalco Chemical	10.8	3
4 W. R. Grace	6219.5	4	PPG Industries	232.5	5	Loctite	9.7	6
5 PPG Industries	3700.0	6	American Cyanamid	166.4	6	Petrolite	7.7	4
6 American Cyanamid	3535.5	5	W. R. Grace	159.7	4	Rohm & Haas	7.5	18
7 Celanese	3261.0	7	Hercules	150.2	8	Air Products	7.0	8
8 Hercules	2629.0	8	Rohm & Haas	141.5	13	Chemed	6.4	7
9 National Distillers	2588.9	9	Celanese	119.0	25	Ethyl	6.4	10
10 Olin	1934.6	11	Air Products	116.9	9	PPG Industries	6.3	13

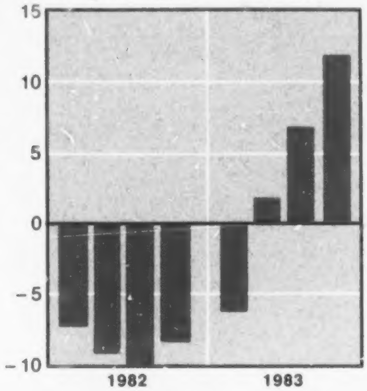
[a] After taxes. **Note:** For 30 companies listed on page 20.

Chemical industry 1983 fourth-quarter results

- Sales were up 12%
- Earnings nearly doubled
- Profit margin rose to 4.8%
- Production climbed 17%
- Prices rose only 2%

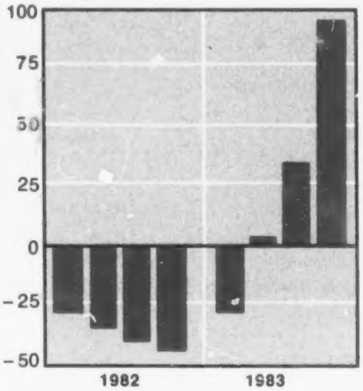
Sales

% change from year-earlier quarter



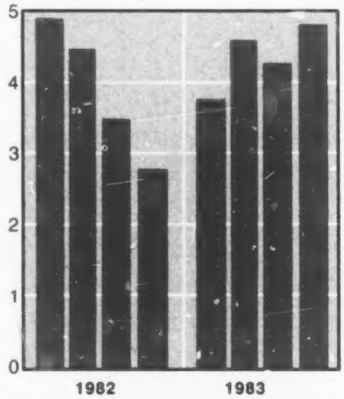
Earnings

% change from year-earlier quarter



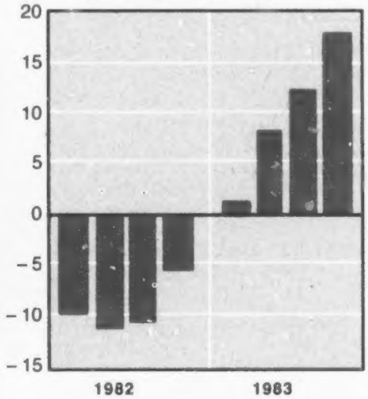
Profit margins

After-tax earnings as % of sales



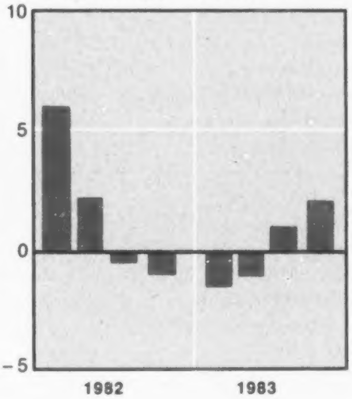
Production

% change from year-earlier quarter



Prices

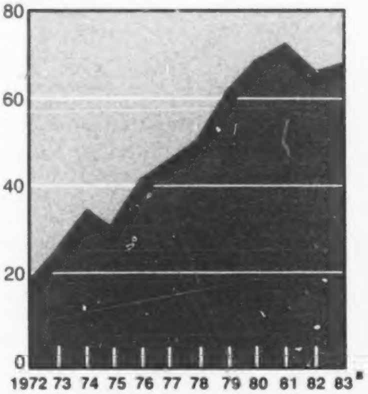
% change from year-earlier quarter



Sales for 1983 were up 3%, and earnings climbed 6% to raise profitability to 4.3%

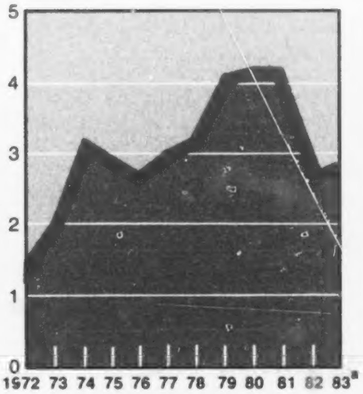
Annual sales

$ Billions



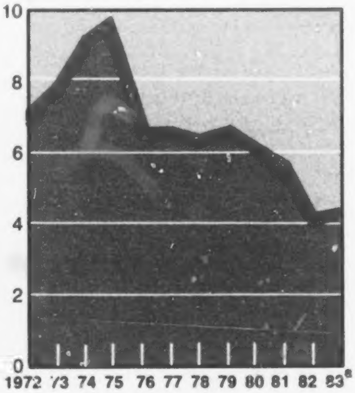
Annual earnings

$ Billions



Annual profit margins

After-tax earnings as % of sales



[a] C&EN estimates. **Note:** All sales, earnings, and profit-margin data are based on the combined results of the 30 companies listed on page 20.

Chemical earnings were up almost 100% in fourth quarter; sales rose 12%

	FOURTH-QUARTER 1983						FULL-YEAR 1983					
	Sales	Earnings[a]	Change from 1982		Profit margin		Sales	Earnings[a]	Change from 1982		Profit margin	
	($ millions)		Sales	Earnings	1983	1982	($ millions)		Sales	Earnings	1983	1982
Air Products	$ 415.9	$ 34.0	8%	75%	8.2%	5.0%	$ 1,662.0	$ 116.9	5%	17%	7.0%	6.3%
American Cyanamid	923.3	55.2	9	42	6.0	4.6	3,535.5	166.4	2	26	4.7	3.8
Celanese	850.0	52.0	20	def	6.1	def	3,261.0	119.0	6	2280	3.6	0.2
Chemed	78.5	4.0	31	43	5.1	4.7	271.3	17.4	9	5	6.4	6.4
Crompton & Knowles	59.0	1.7	16	−32	2.9	4.9	230.6	6.3	8	21	2.7	2.4
Dow Chemical	2,923.0	83.4	14	542	2.9	0.5	10,951.0	273.0	3	−20	2.5	3.2
Ethyl	452.0	32.4	18	24	7.2	6.8	1,745.2	111.8	8	19	6.4	5.8
First Mississippi	54.3	1.9	25	−37	3.5	6.9	222.3	8.8	8	−31	4.0	6.2
Freeport-McMoRan	201.0	23.0	5	8	11.4	11.1	786.2	90.1	5	7	11.5	11.2
H. B. Fuller	110.0	4.1	14	105	3.7	2.1	425.5	13.8	28	60	3.2	2.6
W. R. Grace	1,753.7	58.0	11	7	3.3	3.4	6,219.5	159.7	2	−37	2.6	4.2
Hercules	644.0	42.6	4	61	6.6	4.3	2,629.0	150.2	0	46	5.7	3.9
International Flavors	97.6	11.6	3	22	11.9	10.0	460.9	68.4	3	8	14.8	14.1
International Minerals	356.7	30.3	10	40	8.5	6.7	1,492.7	84.5	−1	14	5.7	4.9
Loctite	56.6	6.0	13	71	10.6	7.0	228.2	22.2	7	63	9.7	6.4
Lubrizol	na	na	na	na	na	3.5	na	na	na	na	na	5.9
Monsanto	1,651.0	78.0	13	225	4.7	1.6	6,299.0	388.0	0	14	6.2	5.4
Morton Thiokol[b]	458.4	44.0	8	25	9.6	8.3	1,829.1	98.0	77	82	5.4	5.2
Nalco Chemical	170.1	17.5	7	17	10.3	9.4	659.4	71.0	2	10	10.8	10.0
National Distillers	706.5	29.8	56	73	4.2	3.8	2,588.9	66.7	41	−16	2.6	4.3
Olin	484.9	12.2	17	97	2.5	1.5	1,934.6	71.7	6	14	3.7	3.4
Pennwalt	245.0	17.9	12	44,650	7.3	0.0	976.7	44.8	3	83	4.6	2.6
Petrolite	71.5	4.8	0	−28	6.7	9.4	287.9	22.1	−5	−25	7.7	9.7
PPG Industries	963.7	67.9	17	63	7.0	5.1	3,700.0	232.5	12	50	6.3	4.7
Reichhold Chemicals	179.3	5.4	1	800	3.0	0.3	747.3	20.1	−5	310	2.7	0.6
Rohm & Haas	433.8	32.6	13	131	7.5	3.7	1,875.9	141.5	3	88	7.5	4.1
Stauffer Chemical	385.0	19.1	−3	355	5.0	1.1	1,326.2	−1.4	−18	def	def	7.3
Union Carbide	2,350.0	58.9	3	95	2.5	1.3	9,000.0	249.1	−1	−20	2.8	3.4
Williams Cos.	na	na	na	na	na	1.4	na	na	na	na	na	1.8
Witco Chemical	361.3	15.1	19	96	4.2	2.5	1,385.7	52.0	6	84	3.8	2.2
Total largest 14 firms[c,d]	**$15,010.2**	**$681.0**	**13%**	**106%**	**4.5%**	**2.5%**	**$55,401.6**	**$2246.5**	**4%**	**9%**	**4.1%**	**3.9%**
Total other 14 firms[c]	**$ 2,425.9**	**$162.4**	**8%**	**62%**	**6.7%**	**4.5%**	**$ 9,500.9**	**$ 520.1**	**0%**	**−5%**	**5.5%**	**5.7%**
GRAND TOTAL[d]	**$17,436.1**	**$843.4**	**12%**	**95%**	**4.8%**	**2.8%**	**$64,902.5**	**$2766.6**	**3%**	**6%**	**4.3%**	**4.1%**

a After-tax income from continuing operations excluding extraordinary and nonrecurring items. b Morton Thiokol's full-year data not comparable. c Division between large and small companies is about $400 million in sales in fourth-quarter 1983. d Totals, per cent change, and profit margin averages for full year exclude Morton Thiokol. na = not available. def = deficit.

to-year increase since that quarter. In the third quarter of 1983 the producer price index was up 1.1%.

Olin's chairman and chief executive officer John M. Henske said, "While the consumer is leading the economy out of its doldrums, there is still some slack in the industrial side, which has made it difficult to get adequate pricing for some of our key products, such as chlorine and caustic soda. During 1983, Olin's overall price index was slightly negative." Henske does not expect the situation to improve until late 1984.

However, during the fourth quarter, production of chemicals and products as reported by the Federal Reserve Board increased 17% from the same period of 1982. This increase in production, combined with the operating efficiencies and cost containment programs put in place by the chemical industry over the past few years, has given chemical companies tremendous earnings leverage. In other words, chemical breakeven points have been lowered enough that even a small increase in the production index translates into a sizable rise in earnings.

A number of chemical company executives commented on this when releasing fourth-quarter results. John D. Macomber, chairman of Celanese, said, "We benefited from our stringent cost control programs of the past two years and our operating margins have increased. We continue to strive for greater efficiency and effectiveness throughout the corporation."

At Pennwalt, chairman Edwin E. Tuttle said, "The combination of improved business conditions and the operating efficiencies we have been able to implement is now resulting in better earnings for an increasing number of the company's profit centers. This is especially true for specialty chemicals."

And Edward G. Jefferson, Du Pont's chairman, said, "Earnings were well ahead of 1982 as the company benefited substantially both from improvements in the economy and from the effects of ongoing cost reduction and productivity improvement programs."

In the fourth quarter, the 95% increase moved combined earnings for 28 of the chemical companies that thus far have reported earnings up to about $843 million. Combined sales for these companies rose 12% to $17.4 billion.

Profitability was much improved over a year before. Profit margins for the chemical firms climbed to an average of 4.8% from 2.8% in the final three months of the year before.

In terms of growth the larger companies on the list by far surpassed the smaller companies. Sales of the 14 larger companies in fourth-quarter 1983 were up 13% from a year earlier to $15.0 billion. Earnings for this group, however, surged 106% to $681 million.

For the 14 smaller companies, fourth-quarter sales totaled $2.4 billion, an 8% increase from the same period of 1982. And earnings increased 62% to $162 million.

The smaller companies still lead the larger ones in profitability, although profitability increased at both. For the 14 larger firms, the average profit margin increased to 4.5% in 1983's fourth quarter from 2.5% the year before; at the 14 smaller companies, the average profit margin climbed to 6.7% in the final quarter of 1983 from 4.5% in the fourth quarter of 1982.

The 95% gain in earnings in the fourth quarter was on earnings from operations excluding nonrecurring items and extraordinaries. These two areas hurt chemical company results as firms took writedowns of less profitable operations and had to contend with some other unusual financial problems. If the extraordinary and nonrecurring items were left in, earnings would have been up 69% instead of 95%. Thus, it can be said that, as usual, companies took advantage of the fourth quarter—and in this case of a good fourth quarter—to shuck off unwanted operations. A number of companies, including Dow Chemical, Union Carbide, and, of the diversified firms, Allied, took large write-offs in last year's fourth quarter.

Jefferson: earnings well ahead of 1982

C&EN staff photo

For the full year, the massive gains in the fourth quarter raised chemical company earnings to the plus side. Earnings for 27 of the 28 companies increased 6% from 1982 to a total of $2.77 billion. (These results exclude Morton Thiokol, whose year-to-year data for the 12 months are not comparable.) Combined sales, however, rose only 3% to $64.9 billion, again showing the earnings leverage of improved operations.

Mahoney: ag business finished strong

Earnings for 13 of the 14 larger companies (again excluding Morton Thiokol) increased 9% from a year before to a combined $2.25 billion. This was on a sales increase of 4% to $55.4 billion.

As with the quarterly results, this was better than the results from the smaller, more specialized firms. Combined earnings at these 14 companies fell 5% to $520 million, and sales were essentially unchanged from 1982 at $9.50 billion.

Thus, full-year profitability for the larger companies increased from 1982 but fell for the smaller firms. Profit margins for the 13 larger companies averaged 4.1%, up from 3.9% in 1982. At the smaller companies, profit margins fell to an average 5.5% from 5.7% the year before. For the 27 companies, total return on sales was up two percentage points in 1983 to 4.3% from 4.1% in 1982.

The improvement in fourth-quarter earnings was led by increased demand in a number of chemical sectors, but chief among these was plastics, as it was in the third quarter. At Dow Chemical, Robert M. Keil, executive vice president and chief financial officer, said of earnings, "The improvement was led by our plastics business. Dowlex linear low-density polyethylene recorded its fifth consecutive year of significant volume growth, and polystyrene showed substantial improvement over last year's difficult market conditions."

At Monsanto, despite nonrecurring charges, fourth-quarter operating income in its polymer products unit increased 64% from a year earlier to $18 million. For the full year, Monsanto's operating income from polymer products rose 287% to $89 million.

And at Du Pont, after-tax operating income from polymer products increased 227% in the fourth quarter to $72 million. For full-year 1983, income from polymer products gained 167% to $208 million.

Allied credits both plastics and fibers for helpings its chemical operations. The company says that

Energy earnings up slightly despite sales decline; diversified earnings climb faster

	% chemical Sales	FOURTH-QUARTER 1983 Sales ($ millions)	FOURTH-QUARTER 1983 Earnings[a] ($ millions)	Change from 1982 Sales	Change from 1982 Earnings	Profit margin 1983	Profit margin 1982	FULL-YEAR 1983 Sales ($ millions)	FULL-YEAR 1983 Earnings[a] ($ millions)	Change from 1982 Sales	Change from 1982 Earnings	Profit margin 1983	Profit margin 1982
OIL AND GAS COMPANIES													
American Petrofina	11	$ 505.0	$ 23.4	−5%	58%	4.6%	2.8%	$ 2,088.5	$ 55.3	−7%	2%	2.6%	2.4%
Atlantic Richfield	8	6,716.6	419.0	−5	−3	6.2	6.1	25,937.4	1547.9	−4	−8	6.0	6.2
Exxon	7	24,663.0	1625.0	−7	10	6.6	5.6	94,591.0	4985.0	−9	19	5.3	4.0
Getty Oil	2	3,050.9	238.9	1	38	7.8	5.7	12,016.0	744.3	−3	8	6.2	5.6
Gulf Oil	7	7,486.0	229.0	−8	24	3.1	2.3	28,887.0	831.0	−6	8	2.9	2.5
Internorth	8	1,593.2	91.2	34	196	5.7	2.6	4,997.0	255.4	20	41	5.1	4.4
Kerr-McGee	13	923.3	17.1	−9	−77	1.9	7.2	3,507.7	118.4	−7	−44	3.4	5.6
Mobil	4	15,578.0	445.0	−6	12	2.9	2.4	58,515.0	1501.0	−9	24	2.6	1.9
Occidental Petroleum	na	4,701.9	292.0	−1	def	6.2	def	19,115.7	480.2	8	252	2.5	0.8
Phillips Petroleum	15	4,150.0	211.0	2	1	5.1	5.1	15,470.0	1.0	−3	0	0.0	0.0
Shell Oil	15	5,245.0	549.0	1	25	10.5	8.5	19,883.0	1633.0	−2	2	8.2	7.9
Standard Oil of California	3	7,441.0	403.0	−6	−5	5.4	5.4	29,182.0	1590.0	−19	15	5.4	3.8
Standard Oil (Ind.)	9	7,400.0	459.0	0	11	6.2	5.6	29,500.0	1868.0	−1	2	6.3	6.1
Standard Oil (Ohio)	4	3,205.0	434.0	0	−6	13.5	14.4	12,067.0	1854.0	−11	−1	15.4	13.9
Sun Co.	3	4,230.0	144.0	3	0	3.4	3.5	15,520.0	523.0	−5	0	3.4	3.2
Tenneco	7	3,841.0	241.0	−1	−13	6.3	7.1	14,449.0	716.0	−4	−15	5.0	5.6
Texaco	3	10,500.0	204.0	−10	−59	1.9	4.2	41,100.0	1129.0	−14	45	2.7	1.6
Unocal (Union Oil)	11	2,680.0	178.0	−2	−21	6.6	8.2	10,690.0	626.0	−2	−22	5.9	7.4
DIVERSIFIED MANUFACTURERS													
Allied	25	2,488.0	118.0	14	174	4.7	2.0	10,022.0	450.0	67	28	4.5	5.9
Aluminum Co. of America	11	1,469.7	75.2	39	81	5.1	3.9	5,263.4	105.3	13	def	2.0	def
Beatrice Foods	5	2,475.6	116.0	7	37	4.7	3.7	9,441.5	358.1	−7	14	3.8	3.1
Borden	30	1,168.9	52.5	8	23	4.5	3.9	4,264.8	160.4	4	16	3.8	3.4
Diamond Shamrock	31	1,177.8	−130.0	56	def	def	6.1	4,026.1	−60.2	27	def	def	4.7
Du Pont	33	9,100.0	331.0	8	61	3.6	2.5	35,400.0	1067.0	6	28	3.0	2.5
Eastman Kodak	20	2,572.0	117.0	−15	−63	4.5	10.6	10,170.0	565.0	−6	−51	5.6	10.7
Engelhard	12	473.8	20.3	−21	18	4.3	2.9	2,099.3	73.5	4	13	3.5	3.2
FMC	38	924.6	68.6	4	22	7.4	6.4	3,498.2	180.9	0	10	5.2	4.7
General Electric	4	7,430.0	579.0	0	10	7.8	7.0	26,800.0	2024.0	1	11	7.6	6.9
Georgia-Pacific	12	1,642.0	104.0	20	447	6.3	1.4	6,469.0	261.0	20	4250	4.0	0.1
Kaiser Aluminum	22	805.2	−0.3	21	def	def	def	2,857.6	−152.7	−2	def	def	def
Koppers	34	447.0	8.8	18	def	2.0	def	1,565.7	24.6	−1	def	1.6	def
Eli Lilly	27	753.1	115.4	5	16	15.3	13.8	3,033.7	457.4	2	7	15.1	14.4
3M	15	1,756.0	163.0	13	8	9.3	9.7	7,039.0	667.0	7	6	9.5	9.6
Merck	21	855.8	104.8	8	5	12.2	12.6	3,246.1	450.9	6	9	13.9	13.6
NL Industries	35	390.1	1.5	−3	−93	0.4	5.3	1,390.1	−18.8	−35	def	def	10.3
Northwest Industries	20	443.5	4.7	35	−29	1.1	2.0	1,608.1	9.6	−19	−95	0.6	9.3
Pfizer	11	972.9	119.2	12	28	12.3	10.7	3,750.0	447.1	7	33	11.9	9.6
Tyler	35	271.7	4.9	25	96	1.8	1.2	960.9	18.4	10	80	1.9	1.2
Uniroyal	27	534.9	15.4	14	def	2.9	def	2,040.3	52.3	4	104	2.6	1.3
Upjohn	17	505.3	33.8	9	37	6.7	5.3	1,986.0	160.2	9	27	8.1	6.9
U.S. Steel	6	4,707.0	166.0	10	def	3.5	def	17,523.0	−12.0	−7	def	def	def
Vulcan Materials	29	232.2	28.3	37	201	12.2	5.6	820.5	54.2	14	−1	6.6	7.6

a From continuing operations excluding extraordinary and nonrecurring items. **def** = deficit. **na** = not available.

in the fourth quarter, income from the chemical segment was substantially higher than in 1982's fourth quarter, reflecting very strong earnings from home furnishing fibers, apparel fibers, high-density polyethylene, engineered plastics, and fluorine products.

Firms whose fibers operations were suffering in fourth-quarter 1982 generally performed very well in the last three months of 1983. Monsanto, for example, swung from a $7 million deficit in fourth-quarter 1982 to a gain of $14 million in its fibers and intermediates unit in fourth-quarter 1983. And Celanese's net income on fibers operations rose 88% during the same period to $1.56 per share.

Also making something of a comeback at a number of companies after a poor year brought on by the government's farm policies were agricultural chemicals—both fertilizers and pesticides. In fertilizers, International Minerals & Chemical says that shipments of potash and phosphate chemicals were strong in the fourth quarter. Phosphate chemical shipments were up 26% from a year earlier and potash shipments increased 44%.

Stauffer Chemical says its agricultural chemical sales for the quarter were encouraging and better than expected, given its new marketing program that will shift the majority of the 1984 season agricultural sales to the January-to-June period. The company is expecting a return to more normal corn planting and stronger demand for its herbicides this spring.

Monsanto says it achieved substantially improved market position during 1983 for its crop chemicals "despite the government's payment-in-kind program." Company president Richard J. Mahoney said, "Our agricultural business finished the year with a strong fourth quarter, reflecting expectations for a good 1984 crop year." Monsanto's fourth-quarter income from agricultural products increased 117% from a year earlier to $78 million. However, income from the same unit for the full year declined 12% from 1982 to $375 million.

The improvement in agricultural earnings may well complete the scene for much better earnings in the first half of 1984. Ag chemicals were practically the last chemical operations to fall into place in the recovery, thanks to the government's policies. The improved outlook for pesticides may well mean that most, if not all, markets for chemicals will see a better first six months in 1984. In fact, considering the weakness of 1983's first half, earnings gains comparable with those of fourth-quarter 1983 are not out of the question. □

Oil companies' chemical earnings solidly in the black

Chemical results at major U.S. oil and gas companies at last have become profitable, both for the quarter and the year. In the fourth quarter of 1982, all but one of eight major oil companies surveyed by C&EN posted a loss in its chemical operations. The one profitable company was Exxon. In 1983's fourth quarter, however, all but two of the firms—Gulf Oil and Texaco— once again were in the black. The eight firms report net earnings from chemical operations on a consistent basis.

For the full year, these same two firms reported losses in chemical operations, whereas in 1982 for the full year, three companies—Atlantic Richfield, Gulf, and Shell, had losing chemical operations.

The eight oil and gas firms reported total chemical earnings in the fourth quarter of about $203 million, up from a loss for the eight in fourth-quarter 1982 of almost $172 million.

For full-year 1983, earnings for the group totaled $457 million, compared with a net loss of about $244 million in 1982.

The only company with positive earnings in the fourth quarters of both 1982 and 1983 was Exxon, whose earnings from chemicals increased 432% to $117 million in the latest quarter. Other companies all improved results, going from losses in fourth-quarter 1982 to gains in the last three months of 1983.

On a full-year basis, two companies had positive earnings in both 1982 and 1983. Exxon's chemical earnings increased 187% from 1982 to $267 million. Getty Oil posted an increase in petrochemical earnings of 201% to $55.4 million.

The reasons for the marked improvement in petrochemical earnings were much the same as for the rise in earnings at basic chemical companies. Gulf says that the turnaround in the economy resulted in higher volumes and prices. Also, the company says, benefits were realized from operating efficiency and cost reduction measures.

At Shell, president John F. Bookout says that chemical earnings for both the quarter and the year benefited from improved margins and higher sales volumes. "Chemical results have continued their steady recovery from recession lows as sales volumes have grown and cost-reduction programs are taking hold," he says.

Texaco, which still showed a loss in the fourth quarter, had pricing problems. Texaco says that in 1983 petrochemical operation results declined both in the U.S. and abroad chiefly because of lower sales prices. But, the company says, the fourth quarter of 1983 showed improvement over the comparable three months of 1982 as a result of increased sales volume in the U.S.

AFTER-TAX EARNINGS ON CHEMICALS

	Fourth quarter			Full year		
$ Millions	1983	1982	% change	1983	1982	% change
Atlantic Richfield	$ 12.0	$−57.0	def	$ 64.0	$−96.0	def
Exxon	117.0	22.0	432%	267.0	93.0	187%
Getty Oil	75.1	−3.6	def	55.4	18.4	201
Gulf Oil	−69.0	−74.0	def	−76.0	−329.0	def
Mobil	8.0	−9.0	def	8.0	24.0	−67
Shell Oil	24.0	−26.0	def	63.0	−25.0	def
Standard Oil (Ind.)	39.0	−7.0	def	99.0	76.0	30
Texaco	−3.0	−17.0	def	−23.0	4.0	def

def = deficit.

Man-Made Fibers Recovery To Continue

The near-term future for man-made fibers looks encouraging. Following last year's recovery from the 1982 downturn, improvement in sales will continue "at least in the first half of 1984," say market research analysts at Enka, the fibers-producing part of Akzo of the Netherlands.

"The chief locomotive will be the U.S. The stronger the recovery there, the quicker will be the upturn in Western Europe," they note in their most recent annual survey of the industry. "Outlook for capital goods is most encouraging. In the automobile and tire industries, growth is anticipated." And a favorable influence on the business climate also is expected from private consumption.

Last year's 5.8% increase in global production of man-made fibers to 31.94 billion lb all but compensated for the 6.7% decline in 1982. Synthetic fibers (up 7.5% to 24.65 billion lb, the highest level ever), mainly contributed to the gain. Cellulosic yarn and fiber output edged up less than 0.6% to 7.29 billion lb.

Cellulosics, indeed, continue to lose ground to synthetics. Of last year's total man-made fibers production, 23% was cellulosics, 77% synthetics. Ten years previously, the split was one third cellulosics, two thirds synthetics. Looked at another way, between 1973 and 1983, cellulosics output declined an average 1.6% per year, whereas synthetic fibers grew an average 3.8% per year.

Among the synthetics, the production split remains much the same as it has been since 1980. Polyester continues to dominate with 48% (about 11.83 billion lb) of the total. Polyamides account for 28% (slightly more than 6.90 billion lb), and acrylic fiber 19% (4.68 billion lb). The 5% balance (1.23 billion lb) mostly comprises elastomerics, polypropylene, and polyvinyl chloride fibers. Compared to 1982, production of these and the polyamides was ahead 1%, whereas that of acrylics and polyesters was down 1%.

During the past 10 years, output of polyester fibers grew an average of 5.4% annually. Next among the major synthetics were acrylic fibers (3.3%), followed by polyamides (1.5%). The other types of synthetic fibers as a whole grew 6.1% a year.

On a regional basis, the U.S. led 1983 man-made fibers production with some 25% (8.03 billion lb) of the total. Next came Western Europe with almost 21% (6.61 billion lb), and Japan with 12% (3.87 billion lb). The other countries of the world combined shared the 42% balance (13.43 billion lb). The geographic split for synthetics was broadly similar—the U.S. had 28% of output (6.97 billion lb), Western Europe 21% (5.10 billion lb), Japan 12% (2.94 billion lb), and the rest of the world 39% (9.64 billion lb).

The 10-year growth profile shows some interesting comparisons. U.S. synthetics output grew at a yearly average rate of 1.6%, whereas in Japan it was a meager 0.5%, and in Western Europe there was essentially no growth at all. In contrast, the other countries lumped together registered an annual rate of increase of almost 12%.

For the U.S. last year, firming in demand resulted in polyester fiber's output improving about 12% from the 1982 level, according to the Enka study, although at 3.56 billion lb, the amount remained some 15% short of 1981. Polyamides did better—the 24% improvement (to 2.41 billion lb) more than compensated for the previous year's decline. Acrylics registered a relatively weak 7% gain (to 667 million lb). □

World man-made fibers output recovered from slump to 1979 level . . .

Billions of lb (% change from previous year)	1983	1982	1981	1980	1979
U.S.	8.03 (6%)	6.95 (−20%)	8.63 (0.6%)	8.58 (−6.7%)	9.20 (8.0%)
Western Europe	6.61 (4.8)	6.31 (−7.3)	6.81 (4.8)	6.50 (−9.6)	7.19 (1.4)
Japan	3.87 (1.3)	3.82 (−2.6)	3.92 (−1.5)	3.98 (−1.0)	4.02 (0.3)
Other	13.43 (2.4)	13.11 (0.7)	13.02 (5.3)	12.37 (6.7)	11.59 (7.2)
TOTAL	**31.94 (5.8%)**	**30.19 (−6.7%)**	**32.37 (3.0%)**	**31.43 (−1.8%)**	**32.00 (5.2%)**

. . . and synthetics reached an all-time high

	1983	1982	1981	1980	1979
U.S.	6.97 (17%)	5.95 (−20%)	7.44 (0.9%)	7.37 (−6.7%)	7.90 (8.6%)
Western Europe	5.10 (7.1)	4.76 (−7.0)	5.12 (8.2)	4.73 (−10)	5.26 (1.5)
Japan	2.94 (1.0)	2.91 (−2.0)	2.97 (−2.0)	3.03 (−1.0)	3.06 (−0.7)
Other	9.64 (3.4)	9.32 (2.9)	9.06 (7.6)	8.42 (9.5)	7.69 (11)
TOTAL	**24.65 (7.5%)**	**22.94 (−6.7%)**	**24.59 (4.4%)**	**22.55 (−1.5%)**	**23.91 (6.4%)**

Source: Enka

Canadian chemical earnings bounced back in 1983

A strong fourth quarter preceded by two other impressive quarters has made 1983 a big turnaround year for the Canadian chemical industry. Gone, in almost all cases, is the red ink that characterized quarterly financial statements in 1982 and the first three months of 1983.

Sales of most Canadian chemical companies bounced back strongly last year, and particularly in the fourth quarter. Profits also have shown a welcome resurgence, although they still languish at levels that are half to a third those in the heyday of 1979 to 1981.

Still, after what the Canadian industry suffered through last year, any improvement in sales and earnings is welcome. Most companies credit the increased sales to higher demand spurred by an improving Canadian and worldwide economy. And, although higher selling prices have contributed to their higher earnings, most chemical companies in Canada are giving most of the credit to belt tightening that they pushed through last year. Reduced inventories, lower capital spending, and better productivity all combined to give them a better earnings picture.

Indicative of the way things went for Canadian chemical companies last year are sales and earnings of the four largest publicly reporting chemical companies, C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide Canada. For the entire year, combined sales of these companies were up a respectable 8.5%. But in the fourth quarter alone, their sales zoomed ahead 19.1%.

Earnings tell a similar story. Combined fourth-quarter earnings were $24.3 million (Canadian), compared to a loss of $5.2 million in 1982. For the entire year, the combined earnings of these four companies swung to a total of $66.7 million from a $15.7 million deficit in 1982.

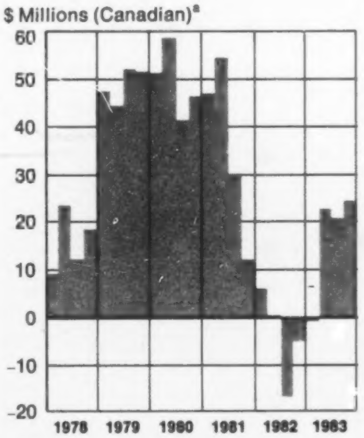
Leading the earnings surge was Du Pont Canada, which posted a $35.2 million profit in 1983 after a net loss of $7.4 million in 1982. The company managed this on sales of $1.1 billion, the second highest in the company's history and 14% higher than in 1982. Du Pont increased sales in Canada 31%, but exports rose only 26%.

Union Carbide remains the only one of the four large chemical companies to suffer a loss last year, despite an 8.8% increase in sales and a $4.1 million profit in the fourth quarter. Company chairman W. Norman Kissick blames continued high taxes levied on oil-based petrochemical feedstocks and a still sluggish steel industry for the lack of profits.

Union Carbide's exports were hit hard last year. Although Canadian sales were up 5%, exports plummeted 44%. Particularly hard hit were polyethylene exports.

On a percentage basis, Celanese Canada's sales grew the most last year, increasing 23% to $398 million. Its earnings reached $9.0 million after a 1982 loss of $5.6 million.

Combined fourth-quarter earnings rose 24%



a After-tax earnings of four largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont Canada, and Union Carbide Canada.

Strong fourth-quarter results were posted by all company divisions. Ernest H. Drew, Celanese president and chief executive officer, says that pricing in Canadian textile markets improved in the fourth quarter, but imports are keeping price pressure on some chemicals.

C-I-L, perhaps the most diversified of the four companies, nevertheless managed to increase sales only 5% last year. But the company was the only one to show a profit both in 1982 and last year; it increased that profit to $23.9 million from $15.2 million in 1982.

C-I-L president and chief executive officer C. H. Hantho expects that continued economic recovery this year will push company sales and earnings even higher. Celanese Canada's Drew agrees. He expects better sales and earnings, but cautions that the improvement could be dampened by a strong Canadian dollar compared to European currencies, by methanol prices, and by the level of textile and garment imports allowed into Canada.

The fortunes of many Canadian chemical firms will be influenced also by the government's response to a recently issued petrochemical task force report (C&EN, Feb. 13, page 4). In its report, the industry is asking government assistance, such as lower feedstock prices and financial aid to revamp oil-based petrochemical plants, so that it can regain its competitive edge in domestic and world markets.

Earl Anderson, New York

Sales up 8.5% for four major Canadian chemical firms

	FULL-YEAR 1983					
					Profit margin[b]	
$ Millions (Canadian)	Net sales	Change from 1982	Net income[a]	Change from 1982	1983	1982
C-I-L Inc.	$1114.0	5.1%	$23.9	57.2%	2.2%	1.4%
Celanese Canada	398.4	23.0	9.0	c	2.3	c
Du Pont Canada	1116.4	13.9	35.2	c	3.2	c
Union Carbide Canada	687.0	−0.6	−1.4	c	d	c
TOTAL	**$3315.8**	**8.5%**	**$66.7**	c	**2.0%**	c

a Net income from continuous operations, excluding extraordinary gains or losses. b Net income as a percentage of sales. c Deficit in 1982. d Deficit in 1983.

EPA Budget Increase Highest For Regulatory Agencies

In reversal of earlier trend, Administration gives EPA 8% rise in fiscal 1985; FDA, OSHA, other agencies get smaller or no spending hikes

For the past few years, the Environmental Protection Agency has served as a first-class example of the Reagan Administration's war on unnecessary and burdensome federal regulation—each new budget proposal contained ever lower funding levels. That trend has now been reversed. Although not all that big, the turnaround is the biggest news in the Administration's generally tight-fisted new budget proposals for regulatory agencies.

The fiscal 1985 budget proposal contains $1.2 billion in operating funds for EPA, a rise of 8% but still 5% less than the agency spent in fiscal 1981. The abatement, control, and compliance budget, which provides the means for assuring that the country's environmental laws are being complied with, would, however, be up less than 1% to $396.0 million, more than 10% below 1981 levels.

Under the proposed budget, spending for the Superfund program will be up 56% to $640 million, with funding for enforcement up 65% to $48.9 million. The agency's overall enforcement budget will be up 27% to $152 million. Also included in the request are increases of 59% to $16.2 million for the pesticide registration program and 28% to $13.7 million for review of existing chemicals under the Toxic Substances Control Act. The budget also contains $1.5 million to enable the agency to initiate a program for regulating commercial uses of genetically engineered materials under TSCA.

Like EPA, the Justice Department is stepping up its enforcement of environmental laws. It is requesting an increase of 13% to $22.6 million for its land and natural resources division. That amount, the department says, will enable it to increase its litigation activities under Superfund 50%.

Other regulatory agencies that in one way or another interact with the chemical community aren't faring so well as EPA. For example, the Food & Drug Administration's budget is slated for a mere 2% rise to $397.6 million, an amount that will allow it to maintain its current level of activities. FDA says that in 1985 it will focus on three priority concerns: bringing safe and effective products to market more rapidly; encouraging voluntary compliance and cooperative industry and government efforts to assist in carrying out agency responsibilities; and keeping FDA's scientific capabilities up to date.

The Occupational Safety & Health Administration's budget also will rise just 2%—to $217.7 billion. The tight budget means that the agency will conduct the same number of inspections in 1985 as it plans this year, 70,500; support the same number of state program inspections, 95,960; and visit the same number of workplaces for consultation, 25,600. OSHA plans to issue eight health and 10 safety standards in 1984. Those numbers will drop to six and seven, respectively, in 1985.

Government support for the Patent & Trademark Office, however, would rise 11% to $101.6 million. That amount would be supplemented by $98.7 million in fees collected for processing patent and trademark applications and disseminating information. PTO says it expects to receive 107,000 patent applications in 1985, the same number as this year, and that total pendency is expected to drop from 25.3 months in 1984 to 24 months in 1985.

EPA's budget would rise 8% . . .

$ Millions	1985ᵃ	1984ᵃ	1983ᵇ
Management	$ 287.8	$ 250.8	$ 240.1
Air	228.8	224.8	214.5
Water quality	217.7	216.2	206.0
Hazardous waste	143.3	128.7	120.1
Toxic substances	79.6	68.8	68.4
Drinking water	79.3	78.7	75.5
Pesticides	63.2	57.3	53.7
Interdisciplinary	48.9	46.1	34.7
Energy	48.5	30.4	25.2
Radiation	12.1	12.3	10.3
TOTAL	$1209.2	$1114.1	$1048.5

Note: Figures include R&D funding

. . . FDA's only 2% . . .

$ Millions	1985ᵃ	1984ᵃ	1983ᵇ
Drugs	$141.3	$138.6	$130.5
Foods	109.3	108.2	103.3
Devices, radiological products	67.0	65.8	58.8
Program management	56.4	54.8	49.4
National Center for Toxicological Research	21.6	21.5	19.6
TOTAL	$397.6	$388.9	$361.6

. . . as would OSHA's

$ Millions	1985ᵃ	1984ᵃ	1983ᵇ
Enforcement	$137.9	$136.3	$130.3
Federal	82.4	81.7	80.1
State	55.5	54.6	50.2
Compliance assistance	37.7	37.6	37.0
Safety and health statistics	16.8	13.0	11.1
Technical support	13.7	13.5	14.1
Safety and health standards	6.2	6.1	6.1
Administration	5.4	6.0	6.7
TOTAL	$217.7	$212.5	$205.3

a Estimate. b Actual. Note: Obligations.

Funding for the Nuclear Regulatory Commission, on the other hand, would drop 2% to $468.7 million. That budget request does allow for some increases. For example, the budget for inspection and enforcement would rise 12% to $92.2 million and that for materials, safety, and safeguards 13% to $45.5 million.

Some of the smaller regulatory agencies are barely holding their heads above water. Funding for the Consumer Product Safety Commission is scheduled to hold steady in 1985 at $35.3 million; the total number of employees will drop by one to 557. In fiscal 1981, for comparison, the agency had a budget of more than $42 million and 889 employees.

Funding for the Council on Environmental Quality, which was set up to review federal government programs having an impact on the environment, would be cut almost in half, from $1.3 million in 1984 to $700,000 in 1985. However, funding for another small office—the Office of Science & Technology Policy—would be up 10% to $2.2 million. Funding for the Office of Management & Budget, which usually manages to find ways to cut the programs other agencies want, will be up again, 8% to $40 million.

Janice Long, Washington

Hydrocarbon wastes to be regulated as a group

"One regulation, rather than 25 individual regulations, will cover the wastes of 25 major commercial products," says Lee M. Thomas, assistant Environmental Protection Agency administrator for solid waste and emergency response. He is explaining a precedent-setting action taken by EPA to list and then regulate specific hazardous wastes as a group rather than individually. The group in this case consists of wastes resulting from the production of 25 chlorinated aliphatic (C_1-C_5) hydrocarbons by free radical catalyzed processes.

In effect, some 37 different toxic compounds, including carbon tetrachloride, vinyl chloride, and benzene, are being regulated under the Resource Conservation & Recovery Act by controlling such manufactured products as dry cleaning liquids and degreasing solvents. It is a unique approach to regulation because it is the first time EPA has regulated using a chemical mechanistic approach.

The toxic and sometimes carcinogenic wastes are generated when petroleum products are chlorinated during their conversion to solvents and polymers. EPA estimates that the manufacturers of the 25 major commercial products covered by the rule annually produce about 180,000 metric tons of chlorinated hydrocarbon-tainted wastes. Each of the 25 different waste streams contains one or more of the 37 toxic compounds in high concentrations.

Ruling covers 25 products

Carbon tetrachloride
1-Chlorobutane (*n*-butyl chloride)
Chloroethane (ethyl chloride)
Chloroform (trichloromethane)
2-Chloro-1,3-butadiene (chloroprene)
Chloromethane (methyl chloride)
2-Chloro-2-methylpropane (*tert*-butyl chloride)
3-Chloro-2-methylpropene (methallyl chloride)
3-Chloropropene (allyl chloride)
Dichlorobutadiene
Dichlorobutenes
1,4-Dichlorobutyne
1,2-Dichloroethane (ethylene dichloride)
Dichloromethane (methylene dichloride)
1,2-Dichloropropane
1,3-Dichloropropene
Hexachlorocyclopentadiene
Tetrachloroethylene (perchloroethylene)
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene (1,1,2-trichloroethene)
1,2,3-Trichloropropane
1,2,3-Trichloropropene
Vinyl chloride (chloroethene)
Vinylidene chloride (1,1-dichloroethene)

This interim final regulation, published in the Feb. 10 issue of the *Federal Register*, becomes final in six months. It follows by four years EPA's previous action that regulated individual waste streams that in the aggregate amounted to 1.5 million metric tons of chlorinated hydrocarbon-contaminated wastes. □

Federal Alert— new regulations

This listing highlights regulations published in the Federal Register *from Dec. 12, 1983, to Jan. 27, 1984. Page numbers refer to those issues.*

PROPOSED

Environmental Protection Agency—Limits emissions of volatile organics from synthetic organic distillation equipment; comments by March 13 (Dec. 30, 1983, page 57538).

Announces required industry toxicity testing for glycidol and derivatives; comments by Feb. 28 (Dec. 30, 1983, page 57562).

Proposes toxicity testing programs by manufacturers for propylene oxide, hydroquinone, and quinone; comments by March 5 (Jan. 4, pages 430, 438, 456).

Sets up toxicity testing program for producers of 1,2-dichloropropane; comments by March 6 (Jan. 6, page 899).

Requires manufacturers to do environmental effects testing on mono-, di-, and trichlorinated benzenes; comments by March 13 (Jan. 13, page 1760).

Gives advance notice of intent to regulate environmental release of 2-methoxy- and 2-ethoxyethanol and their acetates; comments by March 26 (Jan. 24, page 2921).

FINAL

Energy Department—Issues new rules governing price competition for sale of oil from strategic petroleum reserve in case of oil supply cutoff; effective Jan. 20 (Dec. 21, 1983, page 56538).

Environmental Protection Agency—Establishes procedures for carrying out restrictions imposed on imports of hazardous chemicals; effective Dec. 13, 1983 (Dec. 13, 1983, page 55462).

Occupational Safety & Health Administration—Revises record-keeping and reporting requirements for federal employee health and safety programs; effective Jan. 25 (Jan. 25, page 3077).

NOTICES

Environmental Protection Agency—Begins 180-day review of and seeks information on health and safety of workers exposed to 1,3-butadiene for possible regulatory action, acting in concert with OSHA; comments by March 5 (Jan. 5, pages 844, 845).

Declares intent to cancel registration of all pesticide products containing dibromochloropropane; comments by March 12 (Jan. 12, page 1556).

Minerals Management Service—Releases draft environmental impact statement on leasing underwater tracts for mining minerals on the Gorda Ridge, off the northern California coast; comments by Feb. 29 (Jan. 5, page 667).

A1250-1 3/2/84

FEBRUARY 27, 1984

CHEMICAL & ENGINEERING NEWS

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ACS spring meeting, St. Louis
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Electrode surface modification

A new era for electrochemistry
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CONGRESSIONAL INFO SERV
4520 EAST WEST HWY SUITE 800
SRI ACQUISITIONS
BETHESDA MD 20814

Cover: Photomicrograph of modified electrode in which Nafion, a sulfonated fluoropolymer, is coated onto tin oxide. Photo courtesy of Allen J. Bard and coworkers, University of Texas, Austin

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CHEMICAL & ENGINEERING
NEWS
FEBRUARY 27, 1984

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- **U.S. tones down report to UN on chemical warfare in Asia; U.S.S.R. offers concessions to drafting chemical arms treaty.** Page 7
- **Conference Board says current U.S. fiscal policies will lead to recession in 1985.** Page 7
- **Both women and members of minority groups increase their numbers in science and engineering workforce.** Page 8
- **Lower predictions of ozone reduction in the stratosphere are due in part to better measuring techniques.** Page 8

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Business

Research and development limited partnership is an attractive way for companies to get risk money for R&D. **Page 12**

Chemical industry pension funding is more generous than that of overall manufacturing and is better financed. **Page 13**

Government

Update of 1982 report on science and national security indicates government is using stricter controls than recommended. **Page 15**

Technology

Retortable plastic food container with barrier of Saran laminated to polypropylene ready for marketing by Dow Chemical. **Page 20**

Methanol carbonylation and olefins hydrocarboxylation are among ongoing Monsanto projects on catalysis of C_1 systems. **Page 21**

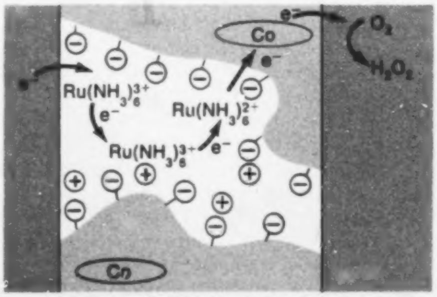
French gasohol project will use lignocellulosic materials via a process developed by U.S. firm to make cattle feed. **Page 22**

Science

Method developed at Columbia uses conformational preferences of large-ring compounds to control reaction stereochemistry. **Page 23**

Final Program

Complete technical session, special events, and preregistration details presented for ACS meeting in St. Louis. **Page 49**



Special Report

Synthesis and application of microstructures on electrodes: promising area of chemistry. **Page 28**

Women, minorities make gains in science

"Despite substantial gains over the past decade, women and minorities are still underrepresented in science and engineering, both in employment and in training," says a new National Science Foundation report.

Between 1972 and 1982, employment of women scientists and engineers increased more than 200%, compared with about 40% for men. As a result, women accounted for 13% of the science/engineering workforce in 1982, the report says. During the same period, the employment of black scientists and engineers almost tripled, whereas the employment of whites rose 40%.

More women and members of minority groups are earning science or engineering degrees than a decade ago. But the report points out that these women and minorities "generally have higher rates of unemployment and lower average salaries than their counterparts." These differences may reflect a variety of factors, including fewer years of work experience, differences in career preferences, and inequitable treatment.

The report notes that "women and minority scientists and engineers who are employed are less likely to hold jobs in science and engineering, although more than 80% do hold such positions." In addition, women and blacks earn 10 to 20% less money than their male and white counterparts.

In 1982, blacks represented 2.6% of all employed scientists and engineers, but more than 9% of the total U.S. workforce. Asians, by contrast, accounted for 4.5% of the employed scientists and engineers, but only 1.6% of the overall U.S. labor force.

The report, "Women and Minorities in Science and Engineering," is the second in a biennial series mandated by public law to present information on the participation of women, racial and ethnic minority group members, and the physically handicapped in science and engineering. Copies of the report (NSF 84-300) are available from the Division of Science Resources Studies, NSF, 1800 G St., N.W., Washington, D.C. 20550; phone (202) 634-4691. □

Employed chemists: men outnumber women . . .

Per cent	Men	Women
All races	86%	14%
White	88	12
Black	43	57
Asian	75	25

. . . but larger share of women are black

Per cent	Men	Women
White	93%	77%
Black	2	13
Asian	4	8

Note: Preliminary data for 1982, subject to revision.
Source: National Science Foundation

Ozone depletion may be less than thought

Better mathematical models and more accurate field measurements have lowered the predicted effect of man-made gases on stratospheric ozone, according to a report prepared for the Environmental Protection Agency by a committee of the National Research Council. Models of the effect of continued release of chlorofluorocarbons into the atmosphere now predict a reduction in stratospheric ozone in the range of 2 to 4% by late in the next century, the committee says. In 1982 an equivalent National Research Council committee predicted a decrease of 5 to 9%, and in 1977 the predicted decrease was 15 to 18%.

Depletions of stratospheric ozone are important because this ozone layer shields Earth from most of the ultraviolet radiation coming from the sun. When the ozone layer is depleted, more ultraviolet radiation reaches the planet's surface, where it is believed to cause increases in human skin cancers, damage plant life, and possibly affect the global climate. Concern about ozone depletion led in 1978 to a ban on almost all uses of chlorofluorocarbons in aerosols in the U.S.

The principal factor responsible for the revision of the predicted ozone depletion has been improved measurements of photochemical rate parameters, the NRC committee says. Studies that use significantly improved measurement techniques have reduced uncertanties and led to revisions in many of these parameters in the past two years. Most of the revisions have led to lower predictions of ozone depletion.

The committee also finds that the more carefully the effects of manmade gases on the ozone layer are studied, the more complicated the problem is seen to be. Studies of the past two years have shown, for example, that there is not a "background" chemical composition of the atmosphere that can be considered to be unchanging in attempting to assess the effect of changing chlorofluorocarbon concentrations. Molecules besides chlorofluorocarbons also are steadily increasing in the atmosphere, including nitrous oxide (N_2O) and methane, and these changes influence the effect of chlorofluorocarbons. Thus models that consider only the effect of changes in chlorofluorocarbon concentration may not show what is really happening in the atmosphere.

Another factor that may be important is that ozone's photochemistry is not the same at different levels even within the stratosphere. Early predictions focused on the changes in ozone concentration predicted for the upper stratosphere (near 40 km), and those calculations have not changed substantially in the past decade. But newer models that take into account changes in other chemical species find that some of these effects are canceled out by increases in the ozone in the lower stratosphere.

Under some scenarios, present models even predict that the lower-level changes might more than cancel out the changes in the upper stratosphere, and total ozone concentrations may increase slightly over the next century. But ozone's chemistry in the lower stratosphere is not nearly so well understood as it is in the upper stratosphere. Three-dimensional models, which have yet to be developed, will be needed to understand this lower region's chemistry, the committee says. □

Update on Science and National Security Report Finds Little Change

Government has yet to relax controls on disseminating basic research results as recommended in the original Corson report

It has been almost a year and a half since the National Academy of Sciences released its report on Scientific Communication & National Security. Although since then incidents have been reported of papers being withdrawn from technical meetings because of Department of Defense objections, matters for the most part have remained calm. That little indeed has happened since the report was issued is shown in an update prepared by two of the staff members, Mitchell B. Wallerstein and Lawrence C. McCray, who worked on the original report. (Both are now on the NAS staff, but their report is not an official one.)

The earlier Corson report, named after study chairman Dale R. Corson, president emeritus of Cornell University, assessed the costs and benefits of government attempts to block communication of basic and sometimes applied research on militarily useful technologies from the Soviets. It generally concluded that the "limited and uncertain benefits" of controls are "outweighed by the importance of scientific progress." That conclusion and the report's 15 specific recommendations were generally endorsed by government agencies.

However, in preparing their update, Wallerstein and McCray found that "the government has not found it possible to act in a manner compatible with the major Corson report principles. In particular, although the government has apparently accepted the report's conclusion that the best form of control is the research funding contract, both the stringency and substantive reach of restrictions now proposed or in force go considerably beyond what was recommended in the report."

For example, the Department of Defense now has a 60-day prior review requirement for sensitive 6.1 (basic) research that is more restrictive than recommended by the Corson panel, which called for simultaneous review by the publisher and DOD. Its 90-day prior review and right to require changes in sensitive 6.2 (nonbasic) research also are far more restrictive than the Corson panel, which did not distinguish between 6.1 and 6.2 research in its recommendations.

It is somewhat reassuring that the update finds no known examples since 1982 in which Export Administration Act regulations actually have been invoked to prevent the dissemination of basic research results. However, the update finds "recent indications that draft technical data regulations under consideration for incorporation into [Export Administration Act regulations] would dramatically alter this situation by removing the general licensing exemption granted to 'scientific and education data.' They would require a validated license for the export of virtually all 'critical technical data.' "

Since, as the update points out, the definition of export includes such things as presentation of papers at symposia where foreigners are present and the hiring of foreign researchers, the proposed regulations have the potential for significantly affecting U.S. scientific enterprises. A lot will depend on just how "critical technical data" are defined.

Universities do very little sensitive research for the government

	Number of reports	Classified, %	Limited, %	Public, %
DOD labs	61,694	12 %	44 %	44 %
Industry	32,806	21	35	44
Universities	23,119	1.3	3.5	95.2
Nonprofit	5,609	17	15	68
TOTAL	123,328	13 %	33 %	54 %

Note: Research reports generated for Department of Energy, Department of Defense, and National Aeronautics & Space Administration.

In 1982 very little was known about the extent to which military research is classified or restricted in some other way. That situation has been remedied by an internal DOD steering committee that looked at the frequency with which reports in the Defense Technical Information Center, the Department of Energy's Technical Information Center, and the National Aeronautics & Space Administration Scientific & Technical Information Center were classified.

According to the update, analysis of the data supported the contention that universities are responsible for less sensitive research than that done in other settings, no matter what field of technology is involved. University-originated reports accounted for about 19% of the 123,328 DOD-sponsored reports in the study; only 1.3% were classified and only 3.5% had any distribution limitations. Every classified report and about 50% of the limited reports were generated in off-campus facilities affiliated with universities. An additional 3% of the limited reports from on-campus projects were judged to be restricted primarily to protect a university's

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proprietary interest. (None of the 4042 chemical research reports identified in the study were classified, and only 14% had a limited distribution.)

One of the Corson report's major recommendations deals with the need to develop a reliable database on which to base a net assessment of the damage to U.S. security from losses occurring through open scientifc communication. There has been little activity in that area. Based on recent intelligence briefings, the update's authors say that "it appears that no major initiatives have been undertaken to characterize better either the overall leakage problem (for example, the relative importance of various sources, channels, and types of information) or the relative significance of scientific information within the larger picture."

More successful have been the Corson report's recommendations concerning the need for more channels of communication between the government and the scientific research community to help alleviate problems arising from ignorance of each other's mindset and working environment. For example, within NAS, a high-level government-industry-academia roundtable has been established to facilitate communication, and an academic panel is being established to advise the State Department on visa approval, denial, or conditionality for scientific visitors from potential adversary countries.

Overall, the update concludes that "for most aspects of the technology transfer problem, we seem to have moved from a period of public controversy to a more subdued period of policy development and implementations. . . . There is little doubt that one useful development since the Corson panel was established has been an enhanced ability to distinguish between the general problem of unwanted technology transfer from all sources and those aspects which pertain to the open communication of scientific information. Despite the possibility of increased targeting in the future, unclassified scientific communication continues at present to be a small part of the overall problem."

Janice Long, Washington

Federal Alert—new legislation

This C&EN listing highlights legislation introduced between Jan. 23 and Feb. 9. Senate and House bills are listed under subject area by bill number, primary sponsor, and committee(s) to which referred.

SENATE

Environment. S. 2215—Glenn (D.-Ohio). Requires reduction in sulfur dioxide emission of 8 million tons per year in 31-state region of eastern U.S. by no later than Jan. 1, 1996, imposes 3 mill-per-kwh fee on fossil-generated electricity to help finance emission controls; referred to Environment & Public Works.

S. 2291—Humphrey (R.-N.H.). Allows EPA access to all remaining funds in hazardous substances response trust fund, rather than just the $410 million appropriated for 1984, limits liability of municipalities for cost of cleaning up municipally owned sites to no more than 50%; referred to Environment & Public Works.

Lobbying. S. 2251—Durenberger (R.-Minn.). Restricts use of federal funds by contractors and grantees with respect to costs knowingly incurred in direct support of "influencing legislation" but exempts activities such as providing technical advice and assistance to governmental officials; referred to Governmental Affairs.

Metric. S. 2223—Pell (D.-R.I.). Requires President's science adviser to undertake comprehensive, one-time study of current status of metric use in U.S.; referred to Commerce, Science & Transportation.

HOUSE

Authorization. H.R. 4797—Fuqua (D.-Fla.). Sets NASA's fiscal 1985 R&D budget ceiling at $2.4 billion; referred to Science & Technology.

Engineering. H.R. 4822—Brown (D.-Calif.). Changes NSF's name to National Science & Engineering Foundation; referred to Science & Technology.

Environment. H.R. 4760—Moody (D.-Wis.). Requires EPA to publish notices of release of hazardous substances from federal facilities, enter into cleanup agreements with the responsible agency that include specific cost estimates of actions to be taken; referred to Energy & Commerce, Public Works & Transportation.

H.R. 4813—Florio (D.-N.J.). Makes the $1.6 billion Superfund permanent, adds $1.8 billion annually to fund for five years by expanding number of basic feedstock chemicals subject to the tax, plus placing a tax on waste brought to disposal facilities; referred to Energy & Commerce.

Trade. H.R. 4590—Derrick (D.-S.C.). Establishes by statute a Committee for the Implementation of Textile Agreements; referred to Ways & Means.

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NUCLEAR FUEL

Pebble form ready for full-scale [illegible]
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Cover: Pebble-bed nuclear reactor at
Schmehausen, West Germany. Photo courtesy of
designer Hochtemperatur-Reaktorbau

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- **Appeals court overturns FTC ruling against Du Pont and Ethyl in price signaling case.** Page 5
- **Polyurethane resin developed for medical use will be marketed in consumer textile products.** Page 5
- **New retrovirus found in blood of monkeys infected with disease similar to human AIDS.** Page 6
- **Du Pont's new supertough polyester molding resin aimed at automotive uses.** Page 6

Business

Early retirement incentive programs enable companies to hold down costs and avoid layoffs but not all retirees benefit. **Page 8**

Government

EPA's ban on agricultural uses of ethylene dibromide triggers the search for alternative pesticides; Canadian officials rap the U.S. Administration for pigeonholing acid rain issue. **Page 13**

Technology

Research on biomass conversion to fuel updated; Dow makes progress in development of Fischer-Tropsch processes for feedstock; traditional views of urea-formaldehyde resins makeup disputed; aluminum alloy decomposes in cold water. **Page 22**

Science

Compound containing easily broken carbon-carbon bonds aids research into making and breaking such bonds. **Page 29**

Books

"Women in Science" depicts contemporary women scientists in their struggle to achieve equality with their male peers. **Page 30**

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Cover Story

Pebble-bed nuclear reactor uses spherically shaped fuel elements that eliminate chance of core meltdown, serve as heat source for chemical operations. Page 20

Early Retirement Incentive Plans Remain Controversial

Part of corporate effort to control personnel costs, plans have been prevalent, leave chemical firms' early retirees with greatly mixed feelings

David Webber, C&EN New York

The past few recessions were tough on chemical companies, and they were tough on employees. Hard times brought hard measures. Even Father Yellow, as once-affectionate employees used to call Eastman Kodak, shed his paternal guise and laid off several thousand personnel. Across the chemical industry, from American Cyanamid to PPG Industries, employees lost their jobs. Management expressed its regrets, but explained that if the industry were to revive, economies were unavoidable.

Those necessary economies, however, did not inevitably entail layoffs. Though some might argue for the dramatic financial effect of outright firings, personnel managers cautioned that terminations can entail hidden costs—costs substantial enough to argue for less drastic, more humane alternatives that could lower the layoff quota. Hard to measure quantities, it was pointed out, like morale, work quality, and a company's image as an employer can, if damaged, inflate the ultimate price of an outright layoff to the point at which the savings become short-term and negligible.

Consequently, two major alternatives—hiring freezes and wage freezes—were adopted widely as ways to avoid terminations. The more money a company could save by putting off salary raises and new hirings—abetted by attrition—the less it needed to eliminate positions. Though wage freezes engender disgruntlement, companies reasoned, they trim personnel costs while inflicting relatively minor pain. Hiring freezes, by definition, cannot harm current employees much.

Still, savings from hiring and wage freezes only lowered the layoff quota; they did not erase it. In the arithmetic of budget cutting, it was obvious that the elimination of one salary at, say, $60,000 a year, with its accompanying fringe benefits, would cut the payroll roughly as much as the elimination of two positions at $30,000 each a year. Most of the higher salaries, companies knew, were earned by older employees with many years of service—employees whose greater experience translated, in general, to broad expertise that was of benefit to the company. On the other hand, companies reasoned, the departure of older employees would open career paths for younger employees of the "baby boom" generation, whose bulge in the demographics of the U.S. as a whole often appears in microcosm in corporate personnel rolls.

Chemical management, of course, could have just fired older employees, but, with the hidden costs of layoffs in mind, many chose instead to turn to the third major alternative—early retirement incentives. The rationale: Offer employees, generally those with enough age and service to qualify for the company's normal early retirement option, an inducement to retire early in the form of a cash bonus and other benefits. If enough accept, several firms say, it is possible to reduce the layoff quota.

Early retirement incentives are a far more delicate means of controlling workforce costs, however, than layoffs, hiring freezes, and wage freezes. There is a legal problem. Almost all early retirement incentive plans are aimed at older workers, and employees over age 40 are protected by the Age Discrimination in Employment Act (ADEA). An employee who felt that he or she did not really have a choice be-

tween accepting or declining the incentive could sue under ADEA, a consequence that could be both expensive and damaging to a company's image.

"Perhaps the single most important consideration in planning these programs is to guard against violating ADEA," Towers, Perrin, Forster & Crosby, a Chicago-based employee benefits consulting firm, warns employers. "Eligible employees must understand that participation in the program is completely voluntary."

In principle, such programs are designed to offer employees free choice. In practice, however, some employees have found the distinction between what was truly voluntary and what was involuntary more than a little murky. The most correctly run plans took great pains to make clear to eligible personnel that their jobs would remain undiminished if they declined the offer. Some firms, like Du Pont, went so far in some cases as to offer early retirement incentives (in the targeted divisions) to all but senior executives so that there could be no taint of age discrimination.

In other firms, some former employees say, there seemed less of the gentlemanliness and more of the ultimatum about the offers. They charge that short deadlines for decision, in some cases, and a clearly implied threat that layoff or, at best, banishment to some corporate backwater would follow rejection of the offer, eliminated the voluntary aspect of the programs. What they received, they say, was an offer they could not refuse.

Even one early retiree who feels that his decision was entirely voluntary concedes that less-appreciated colleagues at his company may not have received the same treatment. "In some of the cases," he says, "people were told, 'Well, your job won't be available as is [if you don't accept the offer]. We'll send you to Siberia.' [The company] wouldn't say this outright, just imply that life wasn't going to be very good."

As a result, there is a wide range of opinion about early retirement incentive programs among chemical company retirees who participated in them during the past few years. Chemical management declares emphatically that the plans were devoid of coercion, that no one was forced out of his or her job because of them, and that for many employees, in fact, the incentives amounted to tremendous cash windfalls.

Still, companies remain extremely sensitive about their early retirement incentive programs. Most are reluctant to say much about them—even though almost all the programs seem to have ended now—and several have refused to supply details on how their programs were conducted. As a result, it is difficult to determine just how prevalent such plans were in the chemical industry during the 1981–83 period. Of 12 major firms willing to comment, however, nine offered at least some employees early retirement incentives during the past two years—not a statistically significant sample, but some indication, perhaps, of the popularity of such programs in the chemical industry during the past recession.

This small sample suggests that chemical companies were in the forefront of a wide corporate move to early retirement incentive programs during the past recession. In a late 1983 survey of 490 major U.S. companies (including some 40 chemical firms and diversified firms with chemical operations), Hay Management Consultants, a Philadelphia-based consulting firm, found that such plans played a large role in workplace cost control efforts between 1981 and 1983. As might be expected, layoffs constituted the most prevalent control on personnel costs; 54.6% of the companies had resorted to them. And 51.8% had implemented a hiring freeze during the period. Less popular were wage freezes; only 29.2% of the companies used them. The approach least chosen, though still important, was the early retirement incentive; 28.2% of the sample had used it.

Many of the largest chemical companies ran early retirement incentive programs—also called "open window" plans, because companies typically limit the period in which an eligible employee can accept or decline to a "window" of a few weeks to a few months—during 1982 and 1983. Those firms which had programs include American Hoechst, Celanese, Dow Chemical, Du Pont, Hercules, Mobay Chemical, Monsanto, Olin, PPG Industries, Rohm & Haas, and Union Carbide. On the other hand, other large companies, including American Cyanamid, Ciba-Geigy, and W. R. Grace, did not.

Although there was a good deal of variation among the different companies' programs, there were certain fundamental similarities.

Early retirement incentive plans played a major role in workforce cost control efforts

Location (No. responding)	% of companies taking action			
	Layoff	Hiring freeze	Wage freeze	Early retirement incentive
Boston (46)	43.5%	45.6%	26.1%	28.3%
Charlotte (27)	59.3	44.4	40.7	22.2
Chicago (60)	66.7	45.0	46.7	38.3
Dallas (40)	85.0	85.0	40.0	25.0
Los Angeles (40)	35.0	27.5	17.5	15.0
Miami (16)	43.8	50.0	12.5	12.5
Minneapolis (51)	50.9	52.9	17.6	29.4
New York (65)	32.3	47.7	18.5	24.6
Pittsburgh (47)	65.9	65.9	46.8	51.1
San Francisco (49)	63.3	46.9	18.4	16.3
Seattle (28)	53.6	53.6	25.0	28.6
Stamford (31)	58.1	61.3	35.5	32.3
TOTAL	**54.6%**	**51.8%**	**29.2%**	**28.2%**
No. of companies	**273**	**259**	**146**	**141**

Note: For period late 1981–late 1983 for 490 companies. **Source:** Hay Associates' "1983 Hay Compensation Conference Proceedings"

"Open window" experiences: some bitter, some sweet

Frank Marsh was a research chemist with 35 years of service in Du Pont's central research department outside Wilmington, Del., when informed in late 1982 that he was eligible for the company's "voluntary termination incentive." Marsh, 63 years old at the time, says he had planned to work to age 66 or 68. Financially, he says, the plan for him was more or less a "break even."

"When the plan was announced, I said to myself, 'This is not for me.' I had no idea of retiring. Nobody worried about being fired. The common reaction was, 'This is not for me.' Almost all my cohorts in my age group said that. Then eventually they did accept it. Almost no one came right out and said this is what I've been looking for. It grew on us slowly. I hated to leave my job. The most frustrating part was not being psychologically prepared to retire.

"It absolutely was voluntary termination. No one was forced out. Some were encouraged, let us say. No one was told, 'You have to retire.' But there are several ways of handling this situation. I'd say 98% were strictly voluntary, and about 2% were encouraged with a, 'You know, it's going to be much better for you if you take it.' The people who were not producing were kind of encouraged, but I think Du Pont would have kept them on forever if they had decided they wanted to stay.

"You are terminated very quickly. One day you're in the thick of it, and the next day you're out cold. Still, Du Pont needed to reduce staff. They did it in a way as best they could. There was every concern for the person. It was done very kindly."

Gilbert Du Pertuis was 57 years old and a senior research chemist at Kerr-McGee's technical center in Oklahoma City, Okla., when informed of his eligibility for an early retirement incentive in October 1982. Du Pertuis, who had been with Kerr-McGee for nearly 30 years, has not yet found another job.

"I don't consider it to have been any kind of incentive at all. I felt I was given a choice of taking early retirement or nothing at all. There was nothing spelled out except the terms of early retirement. But there was nothing in the way of [voluntary] incentive; I wasn't presented with the proposition that I could have this and this and this if I retired then. I was given no choice about whether or not I was going to stay on. We were out. We were given a choice of whether or not we would collect retirement or not. There wasn't any point in not collecting it."

Henry Bader was a Polaroid research fellow, the company's highest scientific grade, when informed of his eligibility for an "open window" program in late 1981. Bader, who was 62 years old at the time and had been with Polaroid for 17 years, says that he received the first unsatisfactory performance rating of his career shortly before the "window" was scheduled to open in February 1982—an anomaly he considers evidence of pressure.

Bader says he also was informed that a regular layoff would follow the early retirement incentive program, at which point his position would be downgraded two levels.

Before this, Bader says, he attended a senior staff meeting at which top management laid out the general goals of the open window program. "I had no idea I would be one of the targets at that time," he says, "but I came out of the meeting with the idea, 'They're getting rid of the old-timers.' "

Bader now works as a bench chemist for a cancer institute attached to Harvard University. He has filed an age discrimination suit against Polaroid, seeking reinstatement of his position there. The case may come to trial later this year, he says.

Typically, for instance, employees had several weeks' notice that a window would be opening. The windows themselves—limited in duration as a means for employers to control the acceptance rate—remained open for four weeks to two months.

At some companies, eligible employee groups included all employees who met age and service requirements. At others, eligibility was limited to salaried personnel, and, in many cases, to salaried personnel in only certain targeted departments. In most of these plans, employees had to be 55 years old or more and had to be vested in the company's pension plan to be eligible.

Acceptance of the offer by eligible employees ranged from 45 to 65%. Consultants who specialize in such plans say that an acceptance rate of 33% is more typical.

Cash bonuses, especially in the more generous offers, were typically computed by multiplying an employee's years of service by an amount ranging from one to two weeks' pay. As a result, some early retirees collected (or are receiving in installments) as much as a year's salary for departing. In addition, many plans paid for accrued vacation time, waived pension benefit reductions that normally apply to early retirements, and continued medical, life insurance, and other benefits to age 65 on the same basis as that for current employees.

As a result, the anecdotal literature of open window plans is replete with tales of 64-year-old employees who, on the verge of normal retirement, suddenly found themselves offered a huge cash windfall to leave their firm a few months before they would have anyway. And there are the stories of employees who turned down the offer, found it necessary a few months later to retire because of illness, for instance, and found that the window had closed.

Nor are employers always assured of success when they launch an early retirement incentive program. Towers, Perrin, Forster & Crosby, for example, points out that since the decision to retire is a highly individual one, it is very difficult to predict the actual number of departures that will occur. There is a danger that too many people will accept the offer, leading to possible serious personnel shortages in individual areas.

"Let's say you get lucky, and exactly a third of your employee group [the acceptance rate that had been targeted] takes the offer," remarks Thomas Jolls, employee benefits consultant in Towers, Perrin's St. Louis office, "but you've got a lab in Akron, Ohio, say, with 10 people in it, and every one of them takes it. You've hit your one-third target, but you've created a devastating problem for that facility."

The difficulty of predicting acceptance rates and concentrations keeps many companies from using the open window option, Jolls says. Firms that are willing to take the risk, he notes, often make contingency plans to cope with unbalanced acceptance rates.

"[These companies] say, 'We'll take our chances, and we will work out suitable transition arrangements if that happens.' So essentially what they do is that they then go to two or three of the people in that group of 10 and they beg. They say, 'Look, you've applied, and you're entitled, but we'd like you to stay on for an additional six months, and we will give you this further economic reward for doing that.' That can work pretty well," Jolls explains.

Another partial solution, he points out, is a quota system. Some companies have set quotas for each department affected by an open window plan. If too many employees decide to accept the offer, the company restricts eligibility to the first to sign up within the limits of the quota.

"That's kind of a clever thing," Jolls says, "because it also stimulates people to get their applications in quickly. One of the characteristics of plans like this is that everybody waits until the last day, and then, by the time everyone involved in administering the program has his or her nails bitten down to their elbows, on the last day you get all the applications."

There is little doubt that early retirement incentives can be a great financial boon to some employees. Many early retirees note that, despite the trauma of suddenly leaving work several years before they had expected to, the money offered was too attractive to pass up. However, not all those who are the subjects of an open window incentive achieve financial security by accepting it. For them, the idea is to follow early retirement from one firm—regardless of whether they felt their acceptance was voluntary—with another job elsewhere. But because of their age, not all have been able to find one.

Jolls: acceptance rates can be problem

"In dollars and cents, it can be very appealing in the short term," says Karen Ferguson, director of the Pension Rights Center, a retiree advocacy organization in Washington, D.C. "They're going to get this money, and they're going to go get another job, and they're going to be in fine shape. But it isn't realistic. Rarely can they find a job, because of age discrimination."

Part of the reason employers and employees don't always perceive a plan's character in the same way may be that there are several possible motives for implementing open window programs, motives that go beyond the desire on the part of companies to limit the need for layoffs. Towers, Perrin, Forster & Crosby lists four basic ways open window programs can help a company during hard times: They can avoid the need for involuntary layoffs; streamline organizational structure; terminate less-productive employees; and open career paths for younger employees. These motives are not mutually exclusive.

Towers, Perrin's Jolls argues that using early retirement incentives for reasons other than avoiding layoffs is not necessarily negative. "We've all met people who are in middle life, who have worked for the same organization for a long time, and who essentially have made their contribution," he says. "They feel stale, but on the other hand, they're at their peak earnings. They do not quite have the financial security to retire, and they are often not emotionally up to the idea of changing jobs, particularly if it means a change in location. So they're sort of stuck. If an individual is in this situation, it's his problem, but if a company has a lot of such individuals, it's a company problem, too. What I've seen happen is that a program like this comes along, and individuals who are in this kind of situation look at it and see that whatever the supplement is, in effect, the individual says, 'Gee, this is just what I wanted. This makes it possible for me to do what I really want to do instead of continuing to work for Megacorporation X in my job, which I once enjoyed, but which no longer stimulates me.' "

Although there is little doubt that there are many cases like this, it seems it would be difficult to prove, however, that such individuals also represent the preponderance of cases. A number of early retirees who spoke with C&EN, including some who were generally pleased with their open window plan, say that they were extremely interested in their work and wish they could somehow continue to pursue it. One chemist, in fact, has suggested to his former employer that it set aside a laboratory in which retired scientists could complete, at reduced pay, projects begun before early retirement.

Clearly, it's a mixed bag. Some employees benefit tremendously; some feel horribly abused. Consultants who help companies organize open window programs believe they are beneficial in general, at least. "It's probably the most tasteful of the vehicles available to handle economic downturns in lieu of layoffs and salary cuts," remarks Kenneth P. Shapiro, president of Hay-Huggins, the actuarial and benefits consulting subsidiary of Hay Associates. ☐

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Gas liquids stay surprisingly strong Page 17

Cover: Arco Chemical's new millisecond
ethylene furnace at Channelview, Tex. Photo
courtesy of technology developer, M. W. Kellogg

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- **If Socal acquisition of Gulf goes through, new company will be U.S.'s third largest chemical-producing oil firm.** Page 4
- **EPA proposes to hasten the phaseout of lead in gasoline to late 1980s.** Page 5
- **Ethylene dibromide limits on fruit set by EPA.** Page 5
- **OSHA head Thorne Auchter steps down.** Page 6
- **Dow Chemical agrees to pay $48,450 to settle EPA complaint over waste disposal.** Page 6

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Business

Major U.S. pharmaceutical companies thrived in 1983, especially on human health care products; Searle was big winner. **Page 8**

Government

Congress works on revenue increases, amendments to the Freedom of Information Act, scholarly exchange of scientific data. **Page 10**

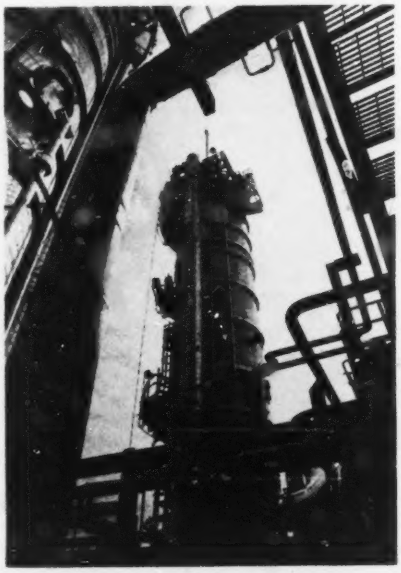
National Research Council study confirms difficulty of assessing commercial chemicals' potential hazard to health due to lack of toxicity testing information, data on human exposure. **Page 12**

Science

Joint effort of chemistry professor and physicians produces argon laser technique to treat congenital heart defect. **Page 14**

Technology

Dow Chemical's trickle-bed electrolytic cell eliminates need for electrolyte recycle, will be used for hydrogen peroxide. **Page 16**



Petrochemical Report

Although gas liquids are still strong as feedstocks for U.S. petrochemicals, smart producers are geared up to switch easily to other raw materials. Page 17

SOCAL TO ACQUIRE GULF: Deal will create broad chemicals line

A new entry in the top 10 U.S. chemical producers is in the making. Under an agreement reached last week, Standard Oil of California will acquire Gulf Corp. for $13.3 billion, or $80 per share. The deal represents the biggest corporate merger in U.S. history, topping the record $10.1 billion that Texaco paid for Getty Oil in January. The purchase, which will make Socal the third largest U.S. oil company and the third largest chemical-producing oil company, is still subject to approval by government antitrust authorities.

The combination of the two corporations' chemical operations will create a broad chemical product line ranging from basic chemicals and fertilizer raw materials to catalysts and electronic chemicals. It will include Socal's Chevron Chemical subsidiary, which along with other Socal chemical units lost $12 million in 1983 (but had net income of $3 million in the fourth quarter); Gulf's Gulf Oil Chemicals subsidiary, heavy in petrochemicals; and Gulf's joint venture with Kaiser Aluminum & Chemical, the Harshaw/Filtrol partnership (managed by Kaiser's Filtrol subsidiary). Gulf's chemical units lost $76 million in 1983 (including a loss of $69 million in the fourth quarter).

Combined, the Socal and Gulf chemical operations would rank high among U.S. chemical producers. In C&EN's ranking of the Top 50 producers, Socal is now 16th and Gulf 33rd. Together, they would be tied for seventh with Celanese, just below sixth-place Shell Oil at sales of just over $3 billion (1982).

Further, the combined chemical enterprise would have little overlap in product lines. Gulf's petrochemicals and specialties are mostly different from Chevron's agricultural and other products.

Socal at a glance

Sales: Full-year 1983—$29.2 billion, down 19% from 1982; fourth-quarter 1983—$7.4 billion, down 6%. Chemical sales 1982—$1.05 billion (3%)

Earnings: Full-year 1983—$1.6 billion, up 15% from 1982; fourth-quarter 1983—$403 million, down 5%. Chemical earnings 1983—loss of $12 million; fourth-quarter 1983—profit of $3 million

Major chemical products (Chevron Chemical subsidiary): Alkylphenols, agricultural and household pesticides, ammonium nitrate, ammonium phosphates, nitric acid, nitrogen solutions, lubricating oil, hydrogen, sulfur, sulfuric acid, alpha-olefins, polybutenes, alkylbenzene, uranium oxide

Chemical sales rank: 33rd

Gulf Oil at a glance

Sales: Full-year 1983—$28.9 billion, down 6% from 1982; fourth-quarter 1983—$7.5 billion, down 8%. Chemical sales 1982—$2.01 billion (7%)

Earnings: Full-year 1983—$831 million, up 8% from 1982; fourth-quarter 1983—$229 million, up 24%. Chemical earnings 1983—loss of $76 million, compared to a loss of $329 million in 1982; fourth-quarter 1983—loss of $69 million, compared to loss of $74 million in 1982

Major chemical products: Benzene, toluene, xylene, sulfur, cyclohexane, cumene, ethylbenzene, styrene, ethylene, propylene, urea-formaldehyde and phenol-formaldehyde resins, polyethylene, polypropylene, catalysts, pigments, electronic and specialty industrial chemicals (the last three by joint venture with Kaiser Aluminum & Chemical)

Chemical sales rank: 16th

To win Gulf, Socal had to beat out three other suitors—Atlantic Richfield Corp.; Kohlberg, Kravis, Roberts & Co., an investment firm that tried to arrange a leveraged buyout; and Mesa Petroleum, which, under the leadership of its chairman, T. Boone Pickens Jr., had been maneuvering for a "hostile" takeover since last August.

The highest bid for Gulf—$87.50 per share—came from Kohlberg, Kravis, Roberts & Co., but Gulf turned it down because the payment would have been only partially in cash, and financing would have taken several months to arrange. Atlantic Richfield, which is reported to have established a large line of credit with banks, tendered the lowest bid—$72 per share. Gulf rejected that as inadequate.

Atlantic Richfield, considered Socal's most serious competition, reacted tersely to the agreement. "Another competitor's bid was selected, and we wish them and Gulf Oil Corp. well in their endeavors," the company stated.

Completion of the acquisition, however, is not altogether assured. Coming so soon after the giant Texaco-Getty merger, the Socal-Gulf agreement has stirred up a hornet's nest in Congress, where a group of both Senators and Representatives are trying to line up support for legislation that would block such transactions for a variety of reasons, ranging from antitrust to protection of jobs. At this point, it is uncertain whether Congressional action, if it were to come about, would come in time to stop the Socal-Gulf merger or might only block similar oil company mergers in the future. The Federal Trade Commission will have to approve the Socal-Gulf deal and could demand certain divestments to satisfy antitrust requirements. Final action could take at least a month.

At the end of the week, Socal pledged to shed any Gulf assets except for oil and gas exploration and production properties to win antitrust clearance. Socal's chief reason for buying Gulf is to increase its oil and gas reserves. The antitrust debate has focused on the large number of gasoline stations the combined company would own.

The reaction in Washington was enough to scare off arbitrageurs and other investors hoping to profit from Socal's tender offer. For example, Gulf stock was the most active issue on the New York Stock Exchange last Thursday, but closed at $64.75 per share, down $4.50 for the day, and more than $15 below Socal's offer. Ordinarily, the stock price of a company about to be acquired rises to more or less the level of the tender offer.

If the government were to block the acquisition by Socal, the Kohlberg, Kravis offer might look more attractive to Gulf. Not only would a leveraged buyout by the investment firm soothe antitrust officials, it probably also would soothe Gulf management, which probably would suffer fewer alterations.

Socal has not discussed publicly its plans for Gulf's extensive chemical operations, which have lost money consistently. Last year, Gulf tried to divest its unprofitable Harshaw Chemical subsidiary but had to settle for the partnership with Kaiser Aluminum & Chemical. Socal's Chevron unit has also performed poorly in recent years.

Top 10 chemical-producing oil companies

$ Billions	1982 chemical sales
Exxon	$7.26
Shell Oil	3.09
Socal-Gulf	3.05
Standard Oil (Ind.)	2.79
Phillips Petroleum	2.36
Atlantic Richfield	2.24
Mobil	2.15
Texaco-Getty Oil	1.69
Occidental Petroleum	1.26[a]
Ashland Oil	1.20

[a] Does not include all chemicals.

The uproar in Congress adds an element of doubt to speculations about other future mergers of large oil companies. However, the merger trend is expected to continue; oil analysts note that it is easier now to find oil reserves on the floor of the New York Stock Exchange than under the Arctic ice cap. ☐

EPA plans to speed up phaseout of leaded gas

The Environmental Protection Agency is drafting proposals to speed up the phaseout of leaded gasoline, according to the agency's Administrator, William D. Ruckelshaus. If history is any guide, the proposals are likely to encounter stiff opposition from some gasoline refiners.

The current limit of 1.1 g of lead per gal of gasoline, which went into effect in 1982, took EPA eight months to establish. It calls for a phaseout of all leaded gasoline by 1990. The stricter proposals now being drafted would further restrict or ban lead use as a gasoline additive by the late 1980s.

The agency's current action apparently was catalyzed by health studies that confirm lead is a toxic air pollutant, and by recent evidence of widespread, illegal use of leaded gasoline in vehicles designed to run only on unleaded fuel. According to Barry D. Nussbaum, a policy analyst in EPA's mobile sources office, about 23% of all car owners in 1982 either had tampered with such things as catalytic converters or improperly switched to leaded gasoline.

Agency officials say studies indicate severe health risks from lead exposure, especially neurological damage, to children in inner-city areas. On the other hand, Ethyl Corp. vice chairman Lawrence E. Blanchard Jr. says there is "no sound evidence linking lead in gasoline and lowering of IQ in children." He claims an EPA-commissioned study last year found no studies that "have validly established a relationship between low-level lead exposure and neuropsychologic deficits in children." Ethyl is a major manufacturer of lead antiknock agents.

According to Gregory Dana, another policy analyst in the mobile sources office, EPA has yet to assess the impact of a stricter lead-in-gasoline rule on small refiners. The agency also has not calculated what savings will accrue to car owners through the use of reduced- or no-lead gasoline, although it says maintenance and repair costs should be lower. Another health benefit would be the elimination of the carcinogen ethylene dibromide, now added to leaded gasoline.

Ruckelshaus says a proposal could be announced as early as April, but some staffers peg the announcement date closer to June. ☐

Ethylene dibromide level on fruit limited

Environmental Protection Agency Administrator William D. Ruckelshaus has made the expected decision limiting the amount of ethylene dibromide on citrus and tropical fruit to 30 ppb. The standard goes into effect in 30 days, but will affect only about 2% of the fruit sold in the U.S.

This most recent action caps the agency's offensive against EDB, which began in September 1983 with the banning of the pesticide's use as a soil fumigant. All foods now have residue standards for EDB, and all U.S. uses of the chemical on food as a pesticide or fumigant have been cut off. Ruckelshaus did not put an immediate ban on the use of EDB as a fruit fumigant, because fruit packers and shippers already have stopped using it on fruit targeted for U.S. markets. EPA still plans to ban EDB's use on fruit completely in September. Some EDB use is still allowed on products intended for exports.

Only fruit traveling to Texas, New Mexico, California, Florida, or Hawaii has to be fumigated in the U.S., and methyl bromide has been substituted for EDB in almost all cases. A gas, methyl bromide doesn't appear to stick to food as EDB does. Residues of methyl bromide on fruit

Drug Profits Up Solidly in 1983

Most major pharmaceutical houses parlayed strong growth in their human health care product lines and general improvement in other, more cyclical, product segments like chemicals to strong sales and earnings gains in the final quarter of 1983 and for the year as a whole. Revenues would have increased even more had not the companies, most of which do a very large share of their business overseas, been hurt by the strength of the U.S. dollar against foreign currencies. Profit margins remained traditionally robust.

A group of 14 of the largest drug firms recorded an overall sales gain of 8% in the fourth quarter and 6% for 1983. Net income rose even more: 14% for the final quarter and 13% for the entire year. The profit margin (after-tax earnings as a percentage of sales) for the group averaged 11.1% in the fourth quarter, compared to 10.5% a year earlier, and 11.2% for the year, compared to 10.5% in 1982.

The impact of the dollar's might on income was deep, a function of most pharmaceutical houses' broad foreign exposure. Pfizer, for instance, recorded some 57% of its 1981 sales abroad. The estimated overseas share that year for Merck was 47%, Bristol-Myers 29%, Warner-Lambert 45%, Eli Lilly 38%, Abbott Laboratories 35%, and Upjohn 38%.

As a result, Pfizer, for one, reports that worldwide sales in 1983, which rose 7% on a dollar basis, actually rose 11% on a local currency basis. Bristol-Myers chairman Richard L. Gelb points out that the company's U.S. sales rose 13%, but international sales increased only slightly because of exchange rates. Sales were reduced $229 million, or 6%, as a result, he says. At Warner-Lambert, chief executive Ward S. Hagan says international sales declined 5% in dollars. Excluding exchange rate changes, he says, they would have risen 5%.

Net income growth also was restrained, in some cases, by increases in the effective income tax rate. At Upjohn, for example, the effective tax rate rose from 24.5% in 1982 to 30.0% last year, accounting for a $12 million reduction in earnings. Upjohn says the higher rate is attributable mostly to the company's having a smaller proportion of total earnings from its tax-exempt Puerto Rican operations than the year before. Merck's effective tax rate expanded to 37% in 1983 from 31% in 1982, and G. D. Searle's tax rate rose about 5% from 1982 to 1983.

Despite generally strong performance by drug product lines, the most spectacular sales gains by a pharmaceutical company came from a nondrug product—the artificial sweetener aspartame. Searle's sales shot up 33% in the fourth quarter and 30% for all of 1983 because of aspartame. The firm's sales of the sweetener totaled $336 million in 1983—or 36% of all sales—compared to $74 million—or 10%—in 1982.

In the fourth quarter, no other major pharmaceutical firm came close to Searle's sales increase. The next highest were Pfizer, Abbott Labs, and A. H. Robins, with increases of 12%, 11%, and 11%, respectively. But other companies made bigger improvements in earnings. Warner-Lambert's net income rose 62%, Upjohn's rose 37%, and Pfizer's rose 28% from the year-earlier period.

David Webber, New York

Major drug firms had a 14% increase in earnings in the fourth quarter

	FOURTH-QUARTER 1983						FULL-YEAR 1983					
	Sales	Earnings[a]	Change from 1982		Profit margin[b]		Sales	Earnings[a]	Change from 1982		Profit margin[b]	
Company	($ millions)		Sales	Earnings	1983	1982	($ millions)		Sales	Earnings	1983	1982
Abbott Laboratories	$802.0	$106.1	11%	21%	13.2%	12.2%	$2927.9	$347.6	13%	20%	11.9%	11.1%
Becton Dickinson	256.2	11.0	7	−16	4.3	5.5	1119.8	29.3	3	−58	2.6	6.4
Bristol-Myers	955.7	103.8	7	17	10.9	9.9	3917.0	408.0	9	17	10.4	9.7
Eli Lilly	753.1	115.4	5	16	15.3	13.8	3033.7	457.4	2	11	15.1	13.9
Merck	855.8	104.8	8	5	12.2	12.6	3246.1	450.9	6	9	13.9	13.6
Pfizer	972.9	119.2	12	28	12.3	10.7	3750.0	447.1	7	33	11.9	9.5
A. H. Robins	145.4	16.9	11	6	11.6	12.2	563.5	67.9	17	30	12.0	10.9
Schering-Plough	434.5	36.2	10	2	8.3	9.0	1808.5	178.5	5	0	9.9	10.3
G. D. Searle	284.4	43.6	33	4	15.3	19.5	946.0	149.1	30	15	15.8	17.8
SmithKline Beckman	717.5	117.4	4	−2	16.4	17.3	2835.4	486.0	7	7	17.1	17.2
Squibb	477.2	43.3	4	19	9.1	8.0	1768.9	173.3	7	13	9.8	9.2
Sterling Drug	480.6	35.5	7	12	7.4	7.1	1901.2	136.8	6	4	7.2	7.3
Upjohn	505.3	33.8	9	37	6.7	5.3	1986.1	160.2	9	27	8.1	6.9
Warner-Lambert	786.0	48.5	5	62	6.2	4.0	3108.3	200.5	−4	23	6.5	5.0

a Excludes extraordinary and nonrecurring items. b After-tax income as a percentage of sales.

Study confirms paucity of chemical toxicity data

A study by a National Research Council committee has documented conventional wisdom: So little toxicity testing and exposure information is available on tens of thousands of important commercial chemicals that assessing their potential hazard to human health is not now possible.

What the three-year, $2.2 million report does do is quantify the extent of ignorance and assess the value of existing toxicity data. For the first time the report offers the National Toxicology Program, which commissioned it, "a much better fix on the extent of what is or is not known, and a good fix on the quality of information available," says John C. Bailar, a Harvard University biostatistician and chairman of the committee's panel on sampling.

Bailar says he realized that there was "very substantial ignorance about the toxicity of materials, even for those substances in use, but I didn't expect it to be as great as it turned out to be." Little toxicity information and even less human exposure data are available for the majority of the chemicals the panel scrutinized closely—pesticides, cosmetics, drugs, food additives, and chemicals in commerce listed under the Toxic Substances Control Act—the reports states. That information void makes it difficult, if not impossible, to assess human health hazards. Even for the more widely tested categories of chemicals, complete health hazard assessments are possible on only 10% of pesticides and inert ingredients of pesticide formulations, and 18% of drugs and inert carrier vehicles.

More important, according to the study, no toxicity information exists for nearly 80% of the chemicals used in commercial products and processes and inventoried under TSCA. However, Garrity Baker, health, safety, and chemical regulations staff executive with the Chemical Manufacturers Association, says "a lot more information is available on toxicity than the study panel had access to." Further, Baker adds, "Health hazard evaluation depends on more than just toxicity data." Other factors that need to be considered are potential for human exposure, the conditions of use, the physical-chemical properties of the chemical, and its structural similarity to other "bad acting" chemicals.

John Doull, a pharmacologist at the University of Kansas Medical Center and cochairman of the committee's panel on toxicity data, acknowledges that the report is "a worst-case analysis." Still, he says, it's a worrisome state of affairs. "As long as we have all those untested compounds, there might be another thalidomide out there." He is referring to the chemical that caused birth defects in infants in the U.K., but which was never marketed in the U.S.

The report, Doull says, does not answer the question, "Is there a big potential health hazard out there?" That wasn't its charge. What it does do is give the National Toxicology Program (NTP) "some hard data about the magnitude of their task," he says. NTP, an agency within the Department of Health & Human Services, selects and tests potentially toxic chemicals.

The study also offers NTP a four-stage process for setting testing priorities. Though philosophically based, as opposed to cookbook specific, the priority-setting concept "will help us do a better job in selecting chemicals for testing," says David P. Rall, director of the National Institute of Environmental Health Sciences and head of NTP. "It tells us how to use the computerized data bases, how to link into them," Rall explains. Still, Bailar cautions, "Putting the scheme into effect will be a major operation."

Rall says the report offers a "fascinating snapshot look at the chemicals in commerce." That may be its most important contribution. By *Chemical Abstracts* reckonings, there are some 5 million known chemicals. About 53,500 distinct substances (65,725 if duplicates are counted) are regulated or inventoried by the Environmental Protection Agency and the Food & Drug Administration. Not all, not even most, can be tested for toxicity. (Even the academy panel could focus only on a selected list of 675 and eventually on a subset of 100 chemicals for their examination.) "It is very important to know how big the universe of ignorance is to know where to start testing," says Ellen Silbergeld, Environmental Defense Fund toxicologist and consultant to the study.

"Toxicity Testing: Strategies to Determine Needs & Priorities" is available from the National Academy Press, 2101 Constitution Ave., N.W., Washington, D.C. 20418 for $22.50.

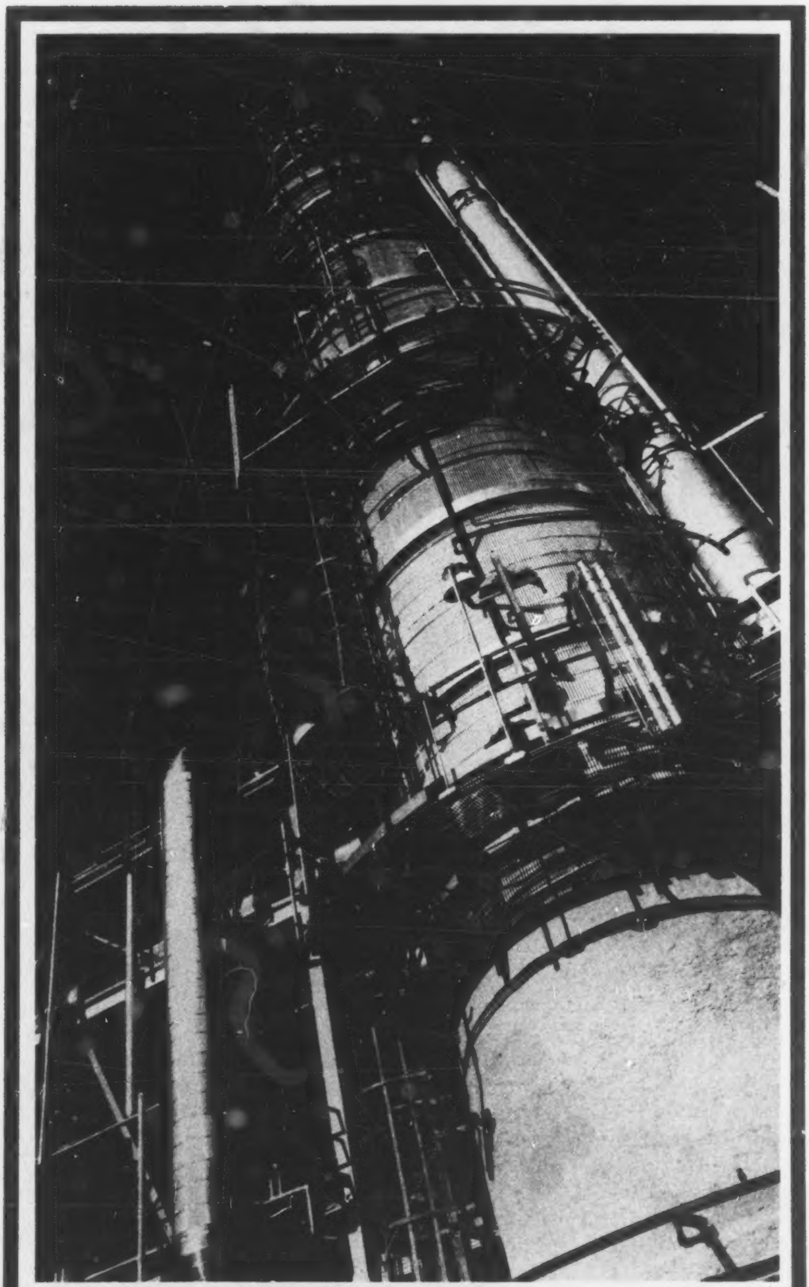
Lois Ember, Washington

Hazard not assessable for most of select 65,725 chemicals

		PER CENT OF CATEGORY				
	Size of category	Complete assessment possible	Partial assessment possible	Minimal toxicity data available	Below minimal toxicity data available	No toxicity data available
Pesticides and inert ingredients of formulations	3,350	10%	24%	2%	26%	38%
Cosmetic ingredients	3,410	2	14	10	18	56
Drugs and inert vehicles used in formulations	1,815	18	18	3	36	25
Food additives	8,627	5	14	1	34	46
Chemicals in commerce: ≥1 million lb per yr	12,860	0	11	11	0	78
Chemicals in commerce: <1 million lb per yr	13,911	0	12	12	0	76
Chemicals in commerce: production unknown or inaccessible	21,752	0	10	8	0	82

PETROCHEMICAL REPORT

Natural Gas Liquids Remain Strong Petrochemical Feedstock



Increasing the demand for butane feedstocks is Monsanto's new maleic anhydride plant, the world's largest, in Pensacola, Fla.

Bruce F. Greek, C&EN Houston

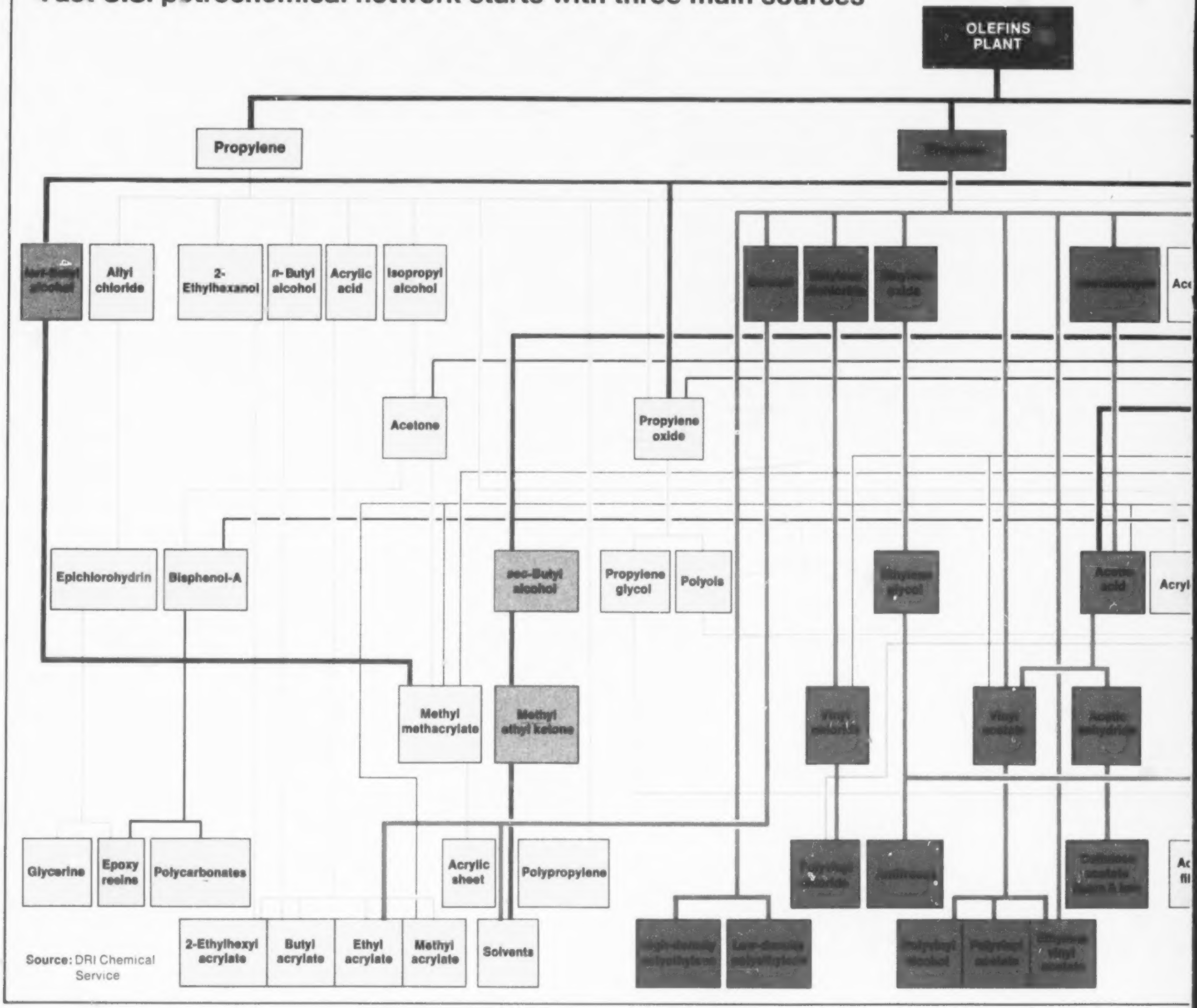
After their most wrenching decade, petrochemicals worldwide have changed in many ways beyond the wildest imagination of the early 1970s. And yet, in other ways, petrochemicals have stubbornly resisted some transformations almost universally predicted.

To size up what has happened to the most basic chemicals of all, and what lies in store, C&EN has visited companies, consultants, and government agencies for this overview. The focus is feedstocks, which have emerged from near obscurity to become by far the dominant cost—and most unpredictable variable—in the petrochemical business.

The ascendancy of raw materials has changed petrochemicals permanently. Growth rates and profitability are much lower now, and international competition has increased greatly. The incredibly complicated web of relationships between feedstocks and other basic hydrocarbons is undergoing computer-aided analysis as never before, and process efficiency is the magic word.

The result for feedstocks in the 1980s is a definite surprise. For the U.S., instead of the wholesale switch widely predicted in the 1970s to oil-based heavy feedstocks, the main trend turned out to be flexibility. Old-fashioned light liquids from natural gas are still highly important in making the dominant olefins as are traditional refinery

Vast U.S. petrochemical network starts with three main sources


OLEFINS PLANT
Propylene
tert-Butyl alcohol
Allyl chloride
2-Ethylhexanol
n-Butyl alcohol
Acrylic acid
Isopropyl alcohol
Ethylene dichloride
Ethylene oxide
Ac
Acetone
Propylene oxide
Epichlorohydrin
Bisphenol-A
sec-Butyl alcohol
Propylene glycol
Polyols
Ethylene glycol
Acetic acid
Acryl
Methyl methacrylate
Methyl ethyl ketone
Vinyl chloride
Vinyl acetate
Acetic anhydride
Glycerine
Epoxy resins
Polycarbonates
Acrylic sheet
Polypropylene
Polyvinyl chloride
Cellulose acetate fibers & tow
Ac fil
2-Ethylhexyl acrylate
Butyl acrylate
Ethyl acrylate
Methyl acrylate
Solvents
Polyvinyl alcohol
Polyvinyl acetate
Ethylene vinyl acetate

Source: DRI Chemical Service

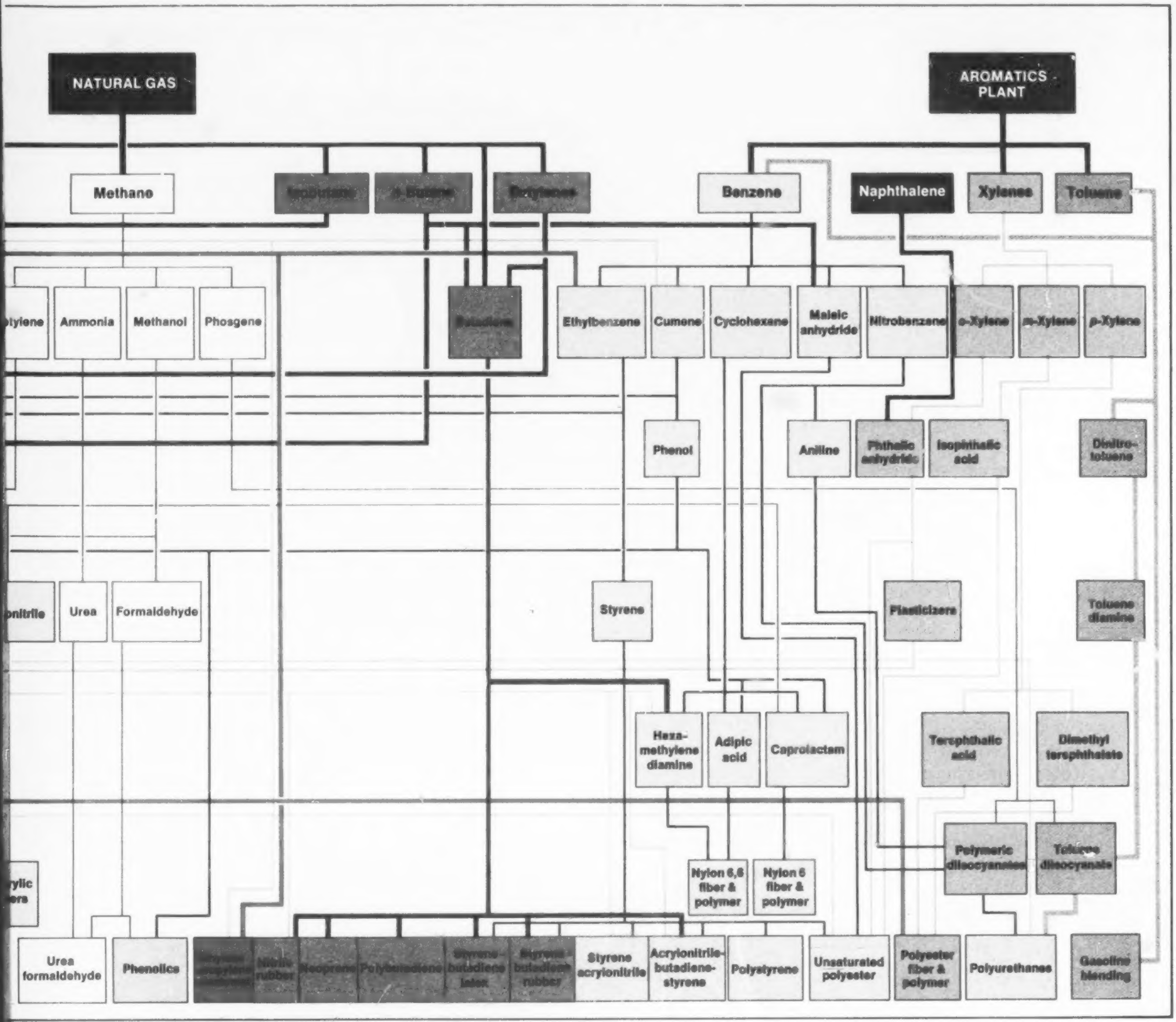
sources in making aromatics. The truly modern petrochemical producer can use practically anything among available feedstocks and may need this flexibility to survive the tangle of influences on choice of feedstock in the rest of the 1980s.

From this point, current thinking is that any change from the present feedstock situation will be gradual. Production growth rates for the rest of this decade are expected to average half or less of those in the 1970s. Hence current worldwide overcapacity will persist much longer than had been forecast.

Demand for petrochemicals in the U.S. is expected to grow more than production, mainly because of a likely decline in net exports of basic petrochemical derivatives as imports surge. For some products, the slump will be steep, for others hardly discernible. And for a fortunate few, a gain in exports could occur. As net exports decline, the U.S. market will have to take up the slack. Even though U.S. demand could grow at a surprising rate, as fabricated plastics capture more markets, the halcyon days of the petrochemical industry are over.

However, the current situation still is far from a struggle for survival. Producers can afford to push hard for all kinds of economies of production and new markets for their products. As might be expected, most attention is going to the biggest and most significant parts of the petrochemical industry— basic olefins and aromatics and their derivative intermediates.

Clearly the most important production route in petrochemicals is steam cracking to make both olefins and aromatics. Steam crackers represent large investments, require


NATURAL GAS
AROMATICS PLANT
Methane
Isobutane
n-Butane
Butylenes
Benzene
Naphthalene
Xylenes
Toluene
tylene
Ammonia
Methanol
Phosgene
Butadiene
Ethylbenzene
Cumene
Cyclohexane
Maleic anhydride
Nitrobenzene
o-Xylene
m-Xylene
p-Xylene
Phenol
Aniline
Phthalic anhydride
Isophthalic acid
Dinitro-toluene
onitrile
Urea
Formaldehyde
Styrene
Plasticizers
Toluene diamine
Hexa-methylene diamine
Adipic acid
Caprolactam
Terephthalic acid
Dimethyl terephthalate
Polymeric diisocyanates
Toluene diisocyanate
rylic ers
Nylon 6,6 fiber & polymer
Nylon 6 fiber & polymer
Urea formaldehyde
Phenolics
Nitrile rubber
Neoprene
Polybutadiene
Styrene-butadiene latex
Styrene-butadiene rubber
Styrene acrylonitrile
Acrylonitrile-butadiene-styrene
Polystyrene
Unsaturated polyester
Polyester fiber & polymer
Polyurethanes
Gasoline blending

huge quantities of feedstocks, and can make product faster than most sales forces can move them. Steam crackers and their auxiliaries therefore get their full share of corporate attention.

Because of their great rise in economic importance, feedstocks account for a very large part of this attention. Technology comes in for lesser, but still important, efforts.

In the early 1970s, feedstock costs were a tenth or less of what they are today in developed countries. Then, feedstocks accounted for a tenth or at most a fifth of the cost of making basic petrochemicals. Plant investment represented a major share of production costs. Now the situation is reversed. Feedstocks represent at least half and sometimes nearly 90% of production costs. They represent most of the cash costs of production.

Petrochemical product prices also jumped over the past decade but not so much as feedstock costs. Prices for basic petrochemicals typically have increased six to eight times their early-1970s prices. The smaller increase for products owes mainly to major efforts by producers to increase process efficiency and shift to feedstocks with higher yields, as well as to reduce various overhead costs. Other price-dampening influences were the lower fraction of costs due to investment and to the much lower profit margins now received by producers. Stiff competition, low capacity use, and customers' price resistance also played a part.

Politics also became a factor. World crude oil prices rose tenfold while U.S. crude oil and natural gas prices remained at controlled prices, at least initially. Later, when U.S.

Petrochemical feedstocks' crucial interplay with fuels

Shadowing petrochemical feedstocks at all times is the enormous U.S. fuels business—gasoline, fuel oil, jet fuel, diesel fuel, and so on. In a myriad of ways, fuels exert a quiet but powerful pull on feedstock prices, frequently sending them up and down independent of petrochemical market forces. It's complex, but it's essential in understanding the ebb and flow of feedstock use.

Fact number one: All hydrocarbons used as petrochemical feedstocks have an alternate use as fuel. This is a basic principle underlying petrochemical economics. It derives from the relatively minor position of petrochemicals as a consumer of crude oil and natural gas—about 7% of the total in recent years.

Fact number two: The alternative fuel value of any hydrocarbon is its lowest value as a petrochemical feedstock. In other words, a hydrocarbon's worth in fuels is a floor value for everything else. Obviously, the fuel value varies enormously with circumstances. An example: Benzene at the moment is inhibited from price increases, despite a big pickup in downstream chemical use, because of weak demand as an octane booster in gasoline. But benzene prices can soar if the gasoline market gets tight as in 1974 and 1979.

The fuel value of hydrocarbons includes more than just the cost of finding, producing, transporting, and otherwise handling them. Political factors can greatly disturb values. One example is diversion of natural gas supplies from industrial plants to consumer markets in cold weather. Another is crude-oil-producing nations' decisions to sell oil and gas above or below production costs depending on political ideology or need for foreign exchange.

Then there's the weather, not a small influence on feedstocks via fuel markets. For example, as a rule petrochemical producers can expect propane prices to rise in the late summer and early fall as fuel consumers fill their tanks for winter. Then in winter, butane prices often rise as the butane fraction in gasoline is raised to increase volatility for better engine starting. Distillate fuel oils also go through price peaks in cold snaps such as earlier this winter.

Besides this seasonal bobbing, hydrocarbon values can edge up or down slowly over many years under long-run influences. For example, natural gas produced in the U.S. has tended to become "drier" (contain less ethane and higher hydrocarbons) with time, thereby reducing the potential hydrocarbon supply. As yet, this trend hasn't greatly affected supplies and prices because of developments such as energy conservation and increased percentage recovery of ethane from natural gas. But in another decade, "dry" gas could start its long-predicted squeeze on gas liquids supply.

In the face of all these long- and short-run shifts, a petrochemical producer must pay a slight premium over the net fuel value of the moment to coax hydrocarbons into feedstocks. Example: To obtain propane for a steam cracker, a company must pay more than the heat content value, handling, and other standard cost factors. This is because the propane seller has an investment in facilities to move the propane to fuel markets that must be covered. In addition, the seller expects to remain in business in heating markets—an intangible temporary-sacrifice factor of some value that also must be covered. In other words, the propane buyer must make it worth the seller's while. Similarly, the fuel value of naphtha to an oil company includes the value of retail service stations and the intangible of

oil prices were decontrolled, naphtha and gas oil prices followed the rise in crude, but the light hydrocarbons—natural gas liquids—rose less. Forecast declines in the availability of natural gas liquids became more and more delayed.

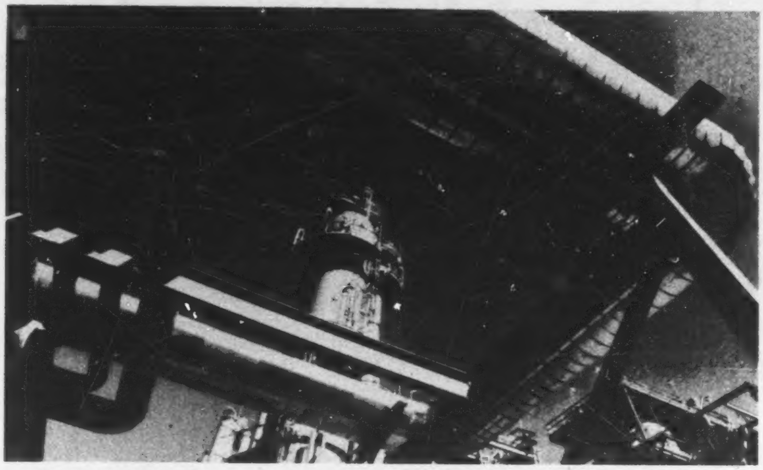
As a result, operators of natural gas-based steam crackers built 10 to 20 years earlier had a clear economic advantage. The others, with oil-based plants, had to do something quickly as the 1970s closed with a second round of world crude oil price increases.

Flexibility became the byword. Almost all steam cracker operators in the U.S. boosted plant investment to gain feedstock flexibility. They haven't all shifted to the ultimate slate running from 100% ethane to 100% vacuum gas oil, the heaviest liquid. But producers can use very large quantities of ethane and propane when prices favor these light hydrocarbons and can make nearly the same shift to heavy hydrocarbons if economics favor them. In effect, basic petrochemical producers now are set up to use any feedstock, depending on economics, and still meet forecast product demand for most of this decade.

Currently, the feedstock slate for U.S. steam crackers still probably exceeds 65% ethane and propane, down from more than 70% in 1976. After slowly losing feedstock share during the late 1970s, to as little as 60% of the total, ethane and propane topped 75% for most of 1982. The down-shift in the late 1970s occurred as a large number of steam crackers designed for heavier feedstocks came on stream. Since then, economic advantages of ethane and propane over naphtha and gas oil reversed the decline, shutting down many heavy feedstock crackers for long periods in the early 1980s.

Some 15 billion lb of annual capacity to make ethylene were added from 1975 to 1982, the great majority based on naphtha or gas oil feedstocks. Heavy feedstock-based capacity in 1975 was about 3 billion lb per year. The remainder of capacity in 1975, some 22 billion lb, was based mainly on ethane and propane feedstocks, with a relatively small part based on refineries' off-gas streams from catalytic cracking operations.

These capacity additions in the late 1970s brought total ethylene capacity to about 41 billion lb nameplate. However, actual operating capacity never reached that much. Even before the last plants of that capacity expansion were finished, the cost advantages of ethane and propane became evident.



Exxon's modernized p-xylene unit near its huge Baytown, Tex., refinery

maintaining share of gasoline markets.

These considerations make it eye-crossing to assess the market value of feedstock hydrocarbons. Computers run hard sorting it out. Their programs scoop up the external cost factors and then add the operating conditions of petrochemical plants. Small changes in plant use can have magnified influences on profitability and change what producers can afford to pay for feedstock.

In spite of these complexities—or perhaps because of their intense analysis—it's hard for a petrochemical producer to gain a large or long-term advantage in feedstock. The refining-petrochemical industries have so many options for feedstock and product slates that advantages or handicaps will be offset sooner or later by other feedstock compositions and product mixes.

As a result, major feedstock shifts tend to happen industrywide rather than by bold individual action. For example, as a result of drawdowns of distillate fuel inventories in cold spells this winter and in anticipation of lower spring demand for heating LPG, prices of ethane and propane have declined significantly since year's end and naphtha/gas oil prices (related to fuel oil) have increased. Now most steam cracker operators have shifted toward the lightest practical feedstock composition, pushing up LPG and holding down naphtha/gas oil, especially since these producers have failed to get ethylene price increases.

Note that this feedstock shift was forced from the raw material side, not the market side, of the petrochemical industry. Because of petrochemicals' relatively small size in the world of basic hydrocarbons, petrochemical product demand seldom has as great an influence on feedstock choice as does the dominant influence of raw material values. This can be true even when market conditions seem superficially to tempt a feedstock shift. For example, the shift in recent years to use more ethane and less naphtha/gas oil meant less production of coproduct propylene and butadiene in steam crackers and potentially higher prices for these olefins. However, all that this economic lure actually did was push up butadiene imports and increase recovery of propylene from refinery streams. In other words, the petrochemical world adjusted internally long before it could nudge the elephantine raw material hydrocarbon business, most of it serving fuels.

The hasty shift to greater flexibility then began. Estimates vary, but capacity that can now use ethane and propane probably has risen to about 35 billion lb per year of ethylene. Unless some of the very old capacity based on ethane and propane comes down, the industry probably could meet 90% or more of ethylene demand using these light hydrocarbons for several years to come if demand forecasts are accurate.

Still in the future as another source of light hydrocarbon feedstocks is international trade in propane. (Shipping ethane by means other than pipeline is too expensive, so significant sea transport is unlikely.) Storage and handling facilities are critical cost items in such trade for chemical use. Even more critical is dependability of supply from politically unstable countries. For these reasons, industry experts believe no plant would be built in the U.S. using imported propane.

Terminals to handle liquefied petroleum gas (LPG), essentially propane and butane, are scattered around the U.S. and various places in Europe, Japan, and other parts of the world. Much of the propane and butane imported to the U.S. comes from Canada and goes mainly to fuel uses. Fuel uses also dominate in other parts of the world. However, potential chemical use in steam crackers is growing in Europe, spurred by the growing availability of gas liquids from the North Sea. European and Japanese terminals are the more likely destinations for ships carrying Middle Eastern and African propane and butane than are U.S. ports.

Just as in the U.S., European feedstock flexibility is growing, mainly to include ethane and propane in steam crackers designed to use naphtha. Again actual feedstocks used day by day depend on competitive feedstock costs.

Complicating the outlook for internationally transported LPG feedstocks are potential exports of ethylene derivatives from many of the same places, such as Saudi Arabia, that provide natural gas liquids. Because ethane is expensive to ship, most of it produced in the Middle East will be converted there to ethylene derivatives, which are expected to be exported, particularly to Europe. If these derivatives do reach Europe in large quantity at lower than competitive prices, ethylene production in Europe will have to be reduced. This could reduce need for gas liquids, even if they are the lowest-cost feedstock. Steam crackers operating on gas liq-

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Cyclohexane

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Isobutane
Isopentane
Isohexane
Isoheptane
Isooctane

30°-60°C Petroleum Ether

Isoparaffinic Mixtures	Typical Boiling Range
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Soltrol* 50	240-300°F
Soltrol* 100	320-345°F
Soltrol* 130	365-405°F
Soltrol* 145	345-535°F
Soltrol* 220 (Mil-F-38299B)	470-540°F

*Trademark for saturated aliphatic hydrocarbons essentially free of aromatics.

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Polyolefins continue to grow fastest among olefin uses

ETHYLENE CONSUMPTION IN END PRODUCTS, BILLIONS OF LB

	Low-density polyethylene	High-density polyethylene	Ethylene oxide	Ethylene dichloride	Ethyl-benzene	All other	Total
1974	6.3	3.0	4.5	3.2	2.0	4.9	**23.9**
1975	5.1	2.8	4.5	2.4	1.5	4.2	**20.5**
1976	6.1	3.3	4.3	3.3	2.0	3.4	**22.4**
1977	6.8	3.8	4.4	3.5	2.2	4.2	**24.9**
1978	7.5	4.4	4.8	4.0	2.4	4.6	**27.7**
1979	8.2	5.3	5.4	4.5	2.5	4.1	**30.0**
1980	7.7	4.7	5.0	3.7	2.1	3.5	**26.7**
1981	7.6	4.8	4.6	3.8	2.1	4.8	**27.7**
1982	7.4	5.1	4.7	3.4	1.7	4.2	**26.5**
1983	8.0	5.9	5.1	3.8	2.0	4.4	**29.2**
1984	8.1	6.4	5.0	4.0	2.0	4.6	**30.1**
1985	8.3	6.7	5.0	4.1	2.0	4.9	**31.0**

PROPYLENE CONSUMPTION IN END PRODUCTS, BILLIONS OF LB[a]

	Polypropylene	Acrylonitrile	Propylene oxide	Isopropyl alcohol	Cumene	All other	Total
1974	2.5	1.8	1.4	1.6	1.2	2.7	**11.2**
1975	2.1	1.6	1.3	1.3	0.8	2.2	**9.3**
1976	2.9	1.9	1.5	1.6	1.1	2.5	**11.5**
1977	3.0	2.1	1.6	1.6	1.1	2.6	**12.0**
1978	3.5	2.2	1.7	1.6	1.3	2.7	**13.0**
1979	4.1	2.5	1.9	1.7	1.6	3.3	**15.1**
1980	3.7	2.3	1.5	1.5	1.3	3.2	**13.5**
1981	4.2	2.4	1.5	1.3	1.3	4.6	**15.3**
1982	3.7	2.4	1.3	1.1	1.1	4.0	**13.6**
1983	4.7	2.5	1.6	1.4	1.3	4.1	**15.6**
1984	5.0	2.6	1.7	1.6	1.4	4.0	**16.3**
1985	5.3	2.6	1.8	1.6	1.5	4.4	**17.2**

a Excludes alkylate (made with isobutane) and other reaction products of propylene used as fuel components. **Sources:** Chemical Market Associates, C&EN estimates based on U.S. International Trade Commission and Society of Plastics Industry data

uids shipped from the Middle East still will have operating costs higher than those operated in the Middle East because of transportation and handling costs. Presumably, derivatives could be exported to Europe less expensively than those made on site.

Even so, current quantities of propane available for export from Saudi Arabia and other Middle Eastern countries are far below forecasts. The major reason is a big cutback in oil production in Saudia Arabia because of weak markets. Lower oil production reduces associated gas and gas liquids production by the same proportion. Most observers now do not anticipate significant near-term gains in exports of propane and butane from the Middle East. Earlier contracted amounts will be supplied, although most contracts apparently have provisions to allow volume reductions as prices rise.

Overall, the trend toward more use of LPG in Europe, Japan, and other regions will come slowly. In the meantime, naphtha and some gas oil will remain the major feedstocks for steam crackers. An expected rise in gasoline demand in Europe could increase the value of naphtha, making chemical producers try to shift to less expensive feedstocks.

The naphtha-gas oil feedstock situation for steam cracking in the U.S. differs. Refinery influences loom large. Here, gasoline volume probably will decline slowly during the 1980s, but octane value will rise. To do this with the low-octane value naphthas produced from the initial distillation of crude oil may require large amounts of aromatics and other octane boosters, divert-

Petrochemicals—a glossary

Aromatics. In common parlance, generally limited to benzene, toluene, and mixed xylenes (plus a small quantity of ethylbenzene). All other aromatics, C_9 and higher, are neglected even though some are sold commercially in small volumes. Naphthalene from coal or petroleum sources is usually considered apart. Aromatics are recovered by extraction from products of catalytic reforming (reformate) in oil refineries, steam-cracking olefins plants (pyrolysis gasoline) and coking of coal (coal tar).

Condensate. A mixture of hydrocarbons, C_5 and higher, produced in natural gas, which are liquid following production from a gas well. The mixture is generally rich in paraffins and low in octane value. Also called "field condensate" or "natural gasoline."

Distillates. Hydrocarbon fractions, largely products of the initial distillation of crude oil, heavier than naphtha up to light lubricating oils. Most are used as fuel products, but some can be feedstocks for steam crackers.

Fuel gas. In petrochemicals, mainly methane and hydrogen produced in cracking processes. Most continues to be burned for energy, but growing needs for hydrogen make separation and purification economically attractive.

Gas oil. A large-sized fraction of crude oil in the boiling range of 400 to 1100 °F. Various adjectival prefixes are used to limit specification of boiling range such as "light" (lower boiling) or "vacuum" (very high boiling). Used as a feedstock in steam- or catalytic-cracking processes; also fractionated to make various fuel products.

Heavy hydrocarbons. Most often C_5 and higher hydrocarbon molecules. "Heavies" in petrochemical and refinery processing include gas oils and naphthas.

Light hydrocarbons. Usually limited to ethane, propane, and butanes. Methane is not included, being considered a separate category.

Liquefied petroleum gas (LPG). Usually limited to propane and butanes in liquid form under pressure at room temperatures. Sometimes includes ethane when mixtures of ethane and propane are used as feedstocks for steam cracking. Major nonchemical use is fuels.

Liquefied refinery gas (LRG). Similar to LPG, but limited to hydrocarbons produced during petroleum refining processes, mainly crude oil distillation.

Naphtha. A petroleum fraction boiling in the range of 100 to 400 °F. Various adjectival prefixes are used to limit specification of boiling range such as "light" or "heavy" depending on use; or "straight run" or "virgin" indicating that source was initial distillation of crude oil. Used as a gasoline component and as a feedstock for processes such as steam cracking; often used alternatively with gas oil, depending on current economics.

Natural gas. Gaseous streams from wells drilled to produce crude oil or natural gas itself. Consists of methane, ethane, propane, butanes, and small amounts of heavier hydrocarbons as well as widely varying amounts of carbon dioxide, hydrogen sulfide, nitrogen, water, and other volatile materials. Usually processed near production sites to remove all materials except methane and some ethane. Sold on basis of either volume or heating value.

Natural gasoline. Hydrocarbons condensed during production of natural gas. Often, propane and butanes are removed, and remaining material is used as a component of motor gasoline or fed to steam crackers.

Natural gas liquids (NGL). Ethane, propane, and higher hydrocarbons found with methane in natural gas. This term frequently used interchangeably with LPG and sometimes with light hydrocarbons.

Octane pool. The average antiknock value of all the hydrocarbon components a petroleum refiner or blendor has available for making gasoline. The monetary value of these components is based on both selling price and their replacement value in making a gasoline of a given octane. This value determines cost petrochemical buyers must pay to remove a given hydrocarbon from a refinery stream for use as a chemical feedstock.

Pyrolysis gasoline. A product stream from steam-cracking olefins plants. Contains a high proportion of aromatics (benzene, toluene, xylenes). Used as a source of individual aromatics or as an octane enhancer for motor gasoline.

Raffinate. Hydrocarbon fraction remaining after solvent extraction of aromatic products from catalytic reforming (reformate) and/or pyrolysis gasoline. Raffinate usually has low octane value and is highly paraffinic, making it useful as a feedstock for steam cracking.

Reformate. Product from catalytic reforming in refineries of hydrocarbon streams high in nonaromatic cyclic compounds. Value depends strongly on octane value of contained aromatics. The source, via solvent extraction technology, of most common aromatics produced in refineries.

Steam cracking. Process of breaking down hydrocarbons in olefins plants at high temperatures in the presence of steam. Precise control of operating conditions required to produce optimum slate of products.

ing them from potential use in chemicals.

Another refinery problem in the making concerns the raffinate left after the aromatics fraction is extracted from reformate. This material has been depleted in aromatics and potentially aromatic hydrocarbons, leaving a highly paraffinic mixture of hydrocarbons, whose response to lead alkyls is relatively poor.

This raffinate could find use in steam crackers as a new feedstock if its price were reduced and if prices of propylene and other coproducts from steam cracking naphtha improved. Raffinate, a material with physical properties similar to naphtha, seems to be waiting in the wings for its chance in making chemicals.

Gas oil, as well as lighter refinery fractions, could become more important as a steam cracker feedstock in 1985 and later. Two cost factors in the world oil and gas industry are behind this potential development. One already has happened—a significant reduction in prices for

Prices for basic petrochemicals have settled since 1981 in line with feedstock costs

Cents per gal, midyear	Crude oil[a]	Ethane	Propane	Butane	No. 2 fuel oil[b]
1973	$ 5.30	3.0¢	9.5¢	7.0¢	11.8¢
1974	9.10	5.9	16.0	18.2	23.0
1975	10.40	9.2	18.0	19.0	26.2
1976	10.90	10.4	19.5	32.0	28.5
1977	12.00	13.9	24.5	25.8	32.4
1978	12.50	14.2	23.5	24.3	33.7
1979	17.70	17.5	27.5	48.6	48.5
1980	28.10	28.0	42.0	54.0	71.9
1981	35.20	31.3	47.0	56.4	89.4
1982	31.90	22.0	36.5	63.2	85.5
1983	29.00	28.1	42.0	72	75
1984	28.80	30	48	75	75

a Dollar per barrel; reflects combination of average of domestic two-tier pricing (when applicable) and average price of imported crude oils. b Roughly equivalent to commercial value of naphtha/gas oil fractions. **Sources:** Department of Energy, C&EN estimates

Cents per lb, annual average	Ethylene	Propylene	Butadiene	Benzene[a]	p-Xylene
1973	3.3¢	3.2¢	8.1¢	3.94¢	6.5¢
1974	7.5	5.5	14.6	8.83	14.7
1975	8.8	7.0	16.5	9.50	14.0
1976	11.2	8.4	17.6	10.5	15.7
1977	12.0	9.5	17.8	10.3	14.7
1978	12.5	9.7	19.4	10.0	12.4
1979	13.8	10.5	22.0	17.9	22.2
1980	21.7	20.2	27.0	21.7	26.0
1981	24.9	23.8	34.0	23.4	31.0
1982	19.8	21.0	35.0	20.6	28.0
1983	20.6	20.0	29.0	20.4	25.0
1984	20.5	19.5	30.0	20.4	27.0

a To convert to common unit of dollars per gallon, multiply by 7.365. **Sources:** U.S. International Trade Commission, C&EN estimates

crude oil. Typically, crude oil prices fell $4.00 to $5.00 per barrel, or from around $34 a bbl to $29 a bbl over the past 18 months. Most analysts no longer forecast continuing large increases in crude prices. (All of them naturally temper forecasts with the assumption that no Middle East war or other crisis will take out a major part of oil supply.) A decline in crude prices makes the heavier hydrocarbon fractions from refineries less expensive as steam cracker feedstocks.

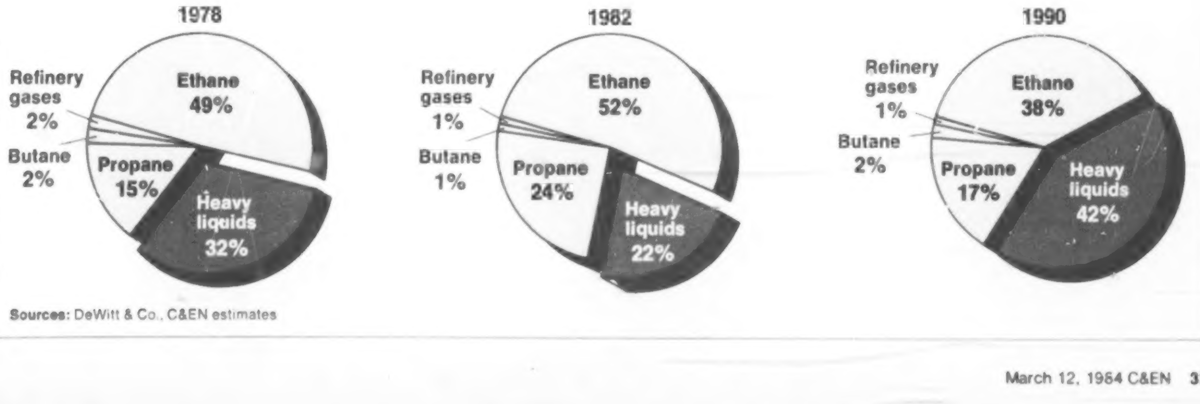
The other cost factor, gas liquids prices, is much less clear. This depends on whether U.S. government controls on natural gas are allowed to expire in 1985. Controls tend to hold down prices of gas liquids by adding incentive to remove them from the gas for additional income. Partial decontrol of gas prices also ranks as a good possibility, making estimates of feedstock costs a bit more complex. If gas prices were completely and abruptly decontrolled, an upward ripple in costs might develop along with some sudden shifts in chemical feedstocks.

However, barring such an extreme move, many steam cracker operators, especially those in special market situations for ethylene derivatives, will prefer ethane and propane feedstock for a long time to come. So the amount of ethylene produced from ethane and propane probably will not decline very much over the next five years. Still, growth in ethylene supplies will come largely from heavier feedstocks, leading to a decline in the fraction from gas liquids.

The question arises of whether another steam cracker fed ethane-propane mixtures will ever be built in the U.S. In the past, analysts have said time and again that "the last ethane-propane cracker has been built"—only to eat their words later. They have said it again about the 1980s, but the possibility of another distinctly exists. Current thinking holds that one will be built but probably not before 1990 unless a field of unexpectedly wet gas (high in liquids) goes into production. If such a steam cracker is built, it probably will have some flexibility to handle heavy hydrocarbons. This would mean a very high capital cost, and a consortium of owners probably would have to be formed to finance the project.

Regardless of whether such a cracker is built, more capacity will be needed toward the end of the 1980s, industry analysts say, despite low average petrochemical growth rates for the rest of the decade. Some earlier shut-down steam cracking ca-

Heavy liquids feedstock use for olefins may expand again after recent 1982 low point



Sources: DeWitt & Co., C&EN estimates pacity based on heavy hydrocarbons is being brought back on stream. And, debottlenecking can add 3 to 5% to capacity over the next two years. When all these additions are noted and scrapped capacity taken off the list, nameplate capacity after 1985 will total 37 billion to 38 billion lb a year of ethylene. If demand reaches 31 billion lb in 1985, the operating rate then will be 85% or higher. So beyond 1985, additional demand growth could require new capacity.

Meanwhile, demand for other basic petrochemicals also will be growing. The rate for some could be higher than for ethylene. Such demand can't be met from the gas liquids crackers very well, especially for aromatics. This points to a need for more use of crackers fed heavy hydrocarbons unless the needed coproducts can be obtained from sources other than U.S. steam crackers, such as refineries or foreign plants.

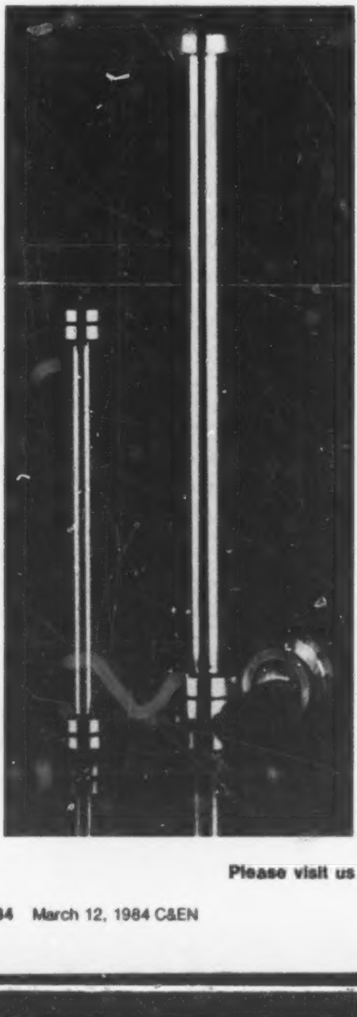
New short-residence-time furnaces up ethylene yields

	% yield from steam cracking light gas oil	
Product	**Conventional furnace**	**Millisecond furnace**
Hydrogen & methane	10.6%	9.7%
Acetylene	0.3	0.5
Ethylene	24.4	27.0
Ethane	3.1	2.6
Propyne	0.5	0.9
Propylene	14.1	13.8
Propane	0.5	0.6
C_4s	10.7	11.8
C_5s (to 390 °F)	15.5	15.9
Fuel oil	20.3	17.2
TOTAL	100.0%	100.0%

Source: M. W. Kellogg Co.

Propylene can be obtained from catalytic cracking units at refineries, but only if purification facilities are available. Butadiene can be made in butylene or butane dehydrogenation plants, although these aren't operating at present because of a wave of imports. Plenty of aromatics are available in refinery reformate, but, as already mentioned, rising gasoline octane requirements can increase the cost of luring aromatics from the gasoline pool for use in chemical intermediates. The net result analysts see from all these influences is that economics will favor more use of heavy feedstocks in steam crackers to give the additional ethylene and coproducts.

A shift in cracker technology such as installing feedstock flexibility also can increase ethylene production. Another technological modification receiving much attention worldwide is increasing ethylene yield at the expense of lower-valued fuel oils and fuel gases. Generally, this technology involves shortening the feedstocks' residence time in the furnaces and raising the temperature. Current residence times at the most advanced new furnaces range below 0.1 second in contrast with up



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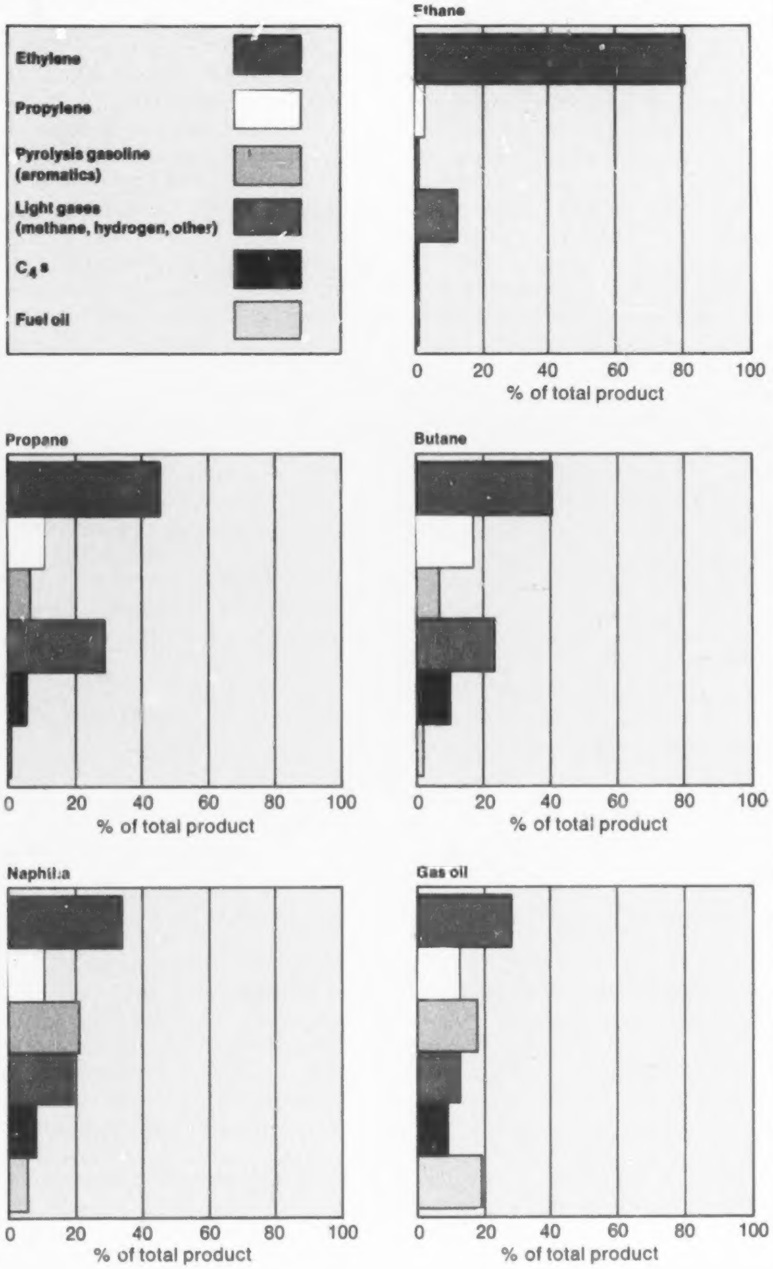
Yields of feedstocks in steam crackers vary widely



Sources: Industry, C&EN estimates

to a full second in older gas liquids crackers. Obviously, shorter residence time can be an energy saver.

Cost gains from such technology jumps can cascade at integrated producers lowering costs at all stages, from feedstock to petrochemical to intermediate to polymer. So producers with a true cost advantage are those with low costs for the whole product chain. In this time of rationalization or restructuring in the petrochemical industry, surviving firms will be those with the better positions for all costs—raw material, manufacturing, and marketing.

Saving energy has been another technology crusade. Since 1972, the chemical industry has reduced its consumption of energy per unit of production about 25%. This has changed the fuel-to-feedstock ratio

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significantly. In 1972, on average, 1.5 bbl of fuel was used for every barrel of feedstock processed. By 1980, conservation measures had reduced that ratio to about 1.1. Analysts forecast that the ratio will reach 1.0 by 1985 and 0.9 by 1990. The drive will continue because of further expected increases in U.S. energy and feedstock costs. In 1980, with U.S. crude oil still under price control, U.S. chemical producers had an international cost advantage of about $8.00 per bbl. When crude oil was decontrolled, the advantage declined to about $6.00 in constant dollars. If natural gas is decontrolled beginning in 1985, the advantage for oil is forecast to drop to $4.00 per bbl.

This kind of energy conservation allied with improved yields from feedstocks could keep the U.S. basic petrochemical industry above the survival stage in its fierce new international competition. Refinements of new technology and operating strategies will further help improve efficiencies and in turn profitability.

U.S., European, and Japanese petrochemical producers probably will never have feedstock and fuel costs as low as those in areas, such as the Middle East, where new petrochemical production has begun. The very competition, however, will keep efforts going to improve efficiencies through all kinds of process innovation. Some markets supplied by existing petrochemical plants will be lost to newer producers in the Middle East, Canada, Mexico, and Asia. These lost markets, however, are being supplied at present by the least efficient plants. Such plants are the logical candidates for shutdown, which will lead to a worldwide efficiency gain.

For the moment, this shakeout is proceeding slowly—too slowly to affect very much the dominant feedstock trends. For Europe and Japan, oil-based liquids are still entrenched. For newer petrochemical producing regions, especially in developing countries, gas liquids are the rule for olefins and refinery streams for aromatics. For the U.S., gas liquids have fooled the experts and are still number one for steam cracking, with refinery streams the main source of aromatics and a strong backup in propylene.

Despite the continuity of gas liquids in the U.S. as petrochemical feedstocks, producers have drastically changed their feedstock stance in the upheavals of the past 10 years. Switchability is the new way of life for producers with long-run survival hopes, and most have spent the money to arrange it. They are not so vulnerable to a sudden feedstock cost shift as they were a decade ago. And they have given petrochemical technology a renewed push to lower process costs and improve yields in the face of a determined market drive from new petrochemical producing regions with vast supplies of low-cost gas liquids. □

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Perkin Medal goes to Exxon's John Sinfelt
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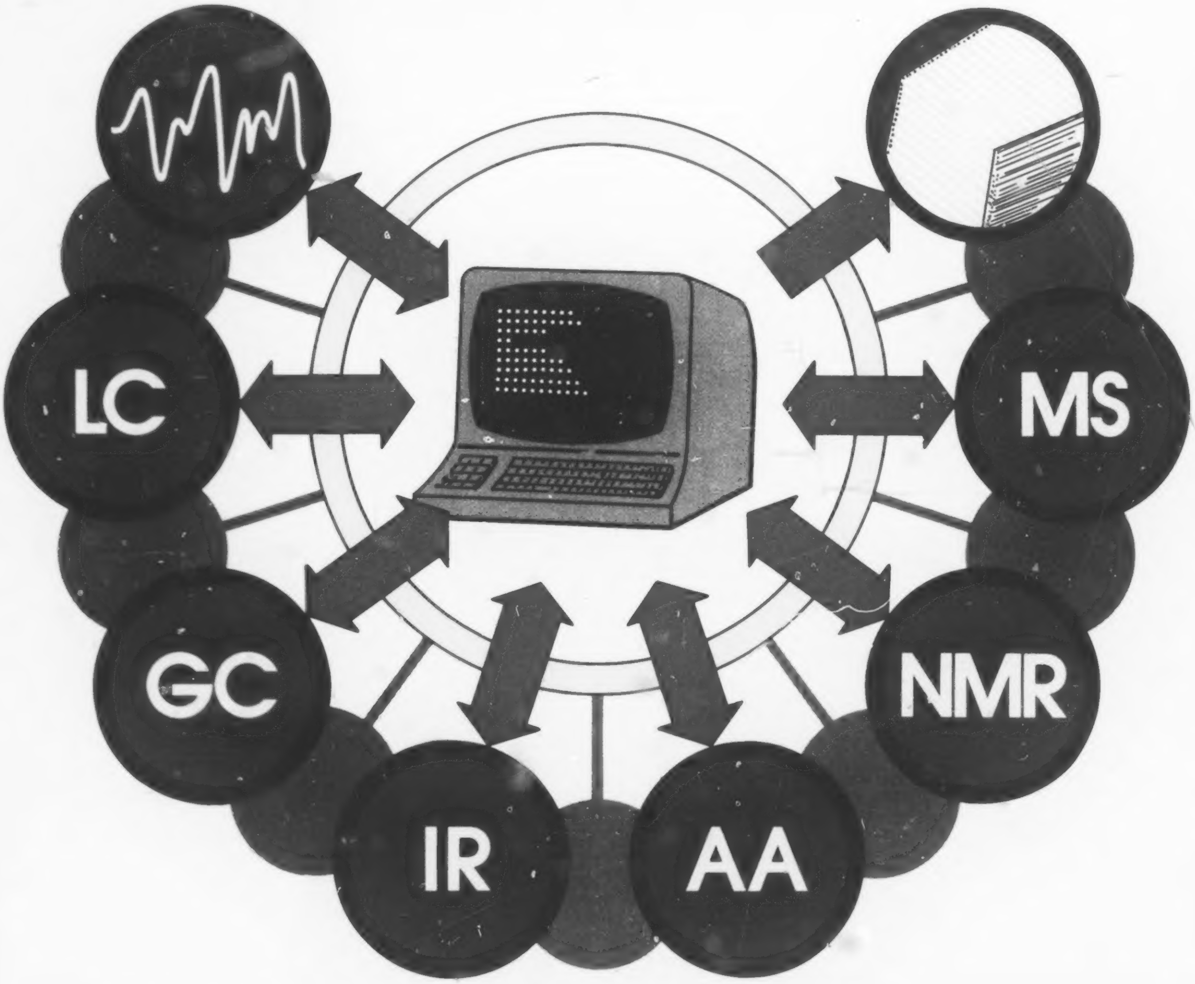

INSTRUMENTATION '84

Software gains prominence at Pittsburgh Conference

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- **Capital spending in the U.S. chemical industry forecast to rise 8% over 1983 level.** **Page 7**
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Perkin Medal

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ACS task force studying chemistry education in the U.S. winds down, will present recommendations at St. Louis meeting. **Page 104**

Instrumentation '84

Computerization—from data stations to networks to LIMS—runs the modern analytical chemistry lab. **Page 31**

Union Carbide to buy large catalyst operation

Union Carbide has furthered its ambitious plans in the catalyst business with a major acquisition. The company has agreed to buy the U.S. and European subsidiaries of Katalistiks International, Baltimore, which produce fluid catalytic cracking (FCC) catalysts for petroleum refining. FCC is a process that cracks gas oil, which is similar to fuel oil, to lighter products while increasing content of octane-boosting aromatic and branched-chain hydrocarbons.

Worldwide sales for FCC catalysts are $500 million, according to H. F. Tomfohrde III, executive vice president and head of Carbide's engineering and technology services group. P. Kenerick Maher, president of Katalistiks International, estimates that the Amsterdam subsidiary has 33% of the European market for these catalysts and 14% of the U.S. market. The Savannah, Ga., plant of the U.S. subsidiary has a capacity of 130 million lb per year FCC catalysts, and the Delfzijl, Netherlands, plant of the Amsterdam subsidiary 55 million lb per year. Meanwhile, Carbide expects to complete a "tons-per-day" FCC catalyst plant in June as a part of expanding its Mobile, Ala., molecular sieves plant.

The worth of the acquisition is still subject to negotiations that may continue till the closing at the end of May, but it will be more than $100 million. Carbide will pay $15 million for assets, technology, and trademarks to each of the three owners of Katalistiks International, who are English China Clays, St. Austell, England; EKA of Göteborg, Sweden; and CRI International, Baltimore. In addition, Carbide will repay $62 million in Katalistiks debt, much of that owed to the three owners.

Tomfohrde says of the acquisition, "Our molecular sieve technology base, combined with Katalistiks' product technology, manufacturing facilities, and worldwide marketing capabilities will enable Union Carbide to enter FCC smoothly, quickly, and with worldwide impact." Tomfohrde adds that the acquisition is part of the firm's plan to become a leader in the $1 billion per-year world catalyst industry. Maher says that FCC catalysts based on Carbide's newest generation of molecular sieves will set a new standard of cracking capacity, stability, and selectivity in petroleum refining.

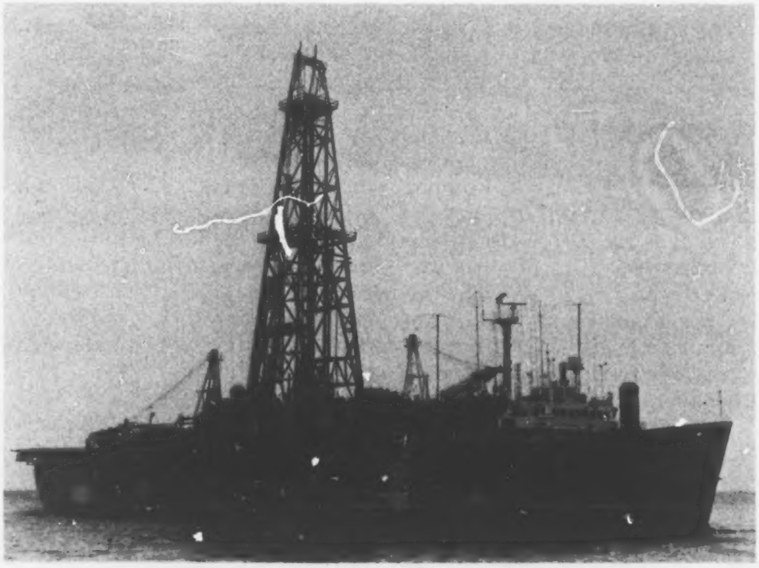
Katalistiks is a feisty new competitor in FCC catalysts. Other U.S. producers include the Davison division of W. R. Grace & Co., Engelhard Corp., and Harshaw/Filtrol. Katalistiks of Baltimore opened its doors in 1982, hiring many management, research, technical service, and sales people from competitors. The firm imported from the Delfzijl plant until 1983, when the Savannah plant started up. Drastic introductory price cuts secured toeholds in a half-dozen cracking units, and Katalistiks has deepened its penetration continuously since then. □

Upturn confirmed in chemical capital funds

Capital spending in the U.S. chemical industry is on a modest rise again after some very low years, according to recent surveys by the Department of Commerce and the Conference Board.

The Commerce Department's just-issued data show that capital spending this year in the U.S. for chemicals and allied products is forecast to rise 8.0% from 1983 to reach $14.34 billion. Last year's spending of $13.28 billion was essentially unchanged from 1982. Commerce's figure for this year is more optimistic than a few months ago, when it showed an increase of 6.3% in 1984.

Still, the Commerce Department's



Drilling ship leased for new sea-floor research project

Texas A&M Research Foundation has reached an agreement for long-term charter of the 470-foot drilling ship *SEDCO/BP 471*, above, to be the research vessel for a newly established oceanographic research project called the Ocean Drilling Program. The program, sponsored by the National Science Foundation and nine foreign countries, is the successor to the 17-year-long Deep Sea Drilling Project, which ended in 1983. Following some modification, the ship will drill various sites on the sea floor to study the history and evolution of the ocean basins, with the first scientific cruise scheduled for January 1985. The ship can accommodate 50 scientists and a crew of 52 and is owned jointly by SEDCO Inc. and British Petroleum. The project will be managed by Joint Oceanographic Institutions Inc., a consortium of 10 major oceanographic institutions. Texas A&M University is providing management support for the scientific research projects.

Appropriations are up, but actual spending still lags

$ Millions 1983[a]	Appropriations	Change from 1982	Spending	Change from 1982
First quarter	$ 1,874	−19%	$2328	−23%
Second quarter	2,371	4	2266	−20
Third quarter	2,964	30	2373	−13
Fourth quarter	2,878	11	2357	−11
TOTAL	$10,087	6%	$9324	−17%

a Plant and equipment in the U.S. for chemicals and products.
Source: Conference Board

forecast falls short of the 12% growth in U.S. capital spending expected by chemical companies in C&EN's survey at the end of last year. The same companies expected worldwide spending up more than 14% (C&EN, Dec. 12, 1983, page 10). The difference may arise because the Commerce Department's sample includes companies producing a wide range of chemical products, whereas the C&EN sample is made up mainly of basic chemical companies.

More evidence of a 1984 spending pickup comes from the New York City-based Conference Board in its quarterly report on capital appropriations (monies allocated, but not yet spent, for capital projects). The report shows that such appropriations for chemicals and allied products in the fourth quarter of 1983 reached $2.88 billion, an 11% increase over fourth-quarter 1982 but a drop of 2.9% from third-quarter 1983. For full-year 1983, capital appropriations totaled about $10.1 billion, a 6.4% increase over 1982.

Actual capital spending in the fourth quarter, according to the Conference Board, totaled $2.36 billion, down 11.4% from fourth-quarter 1982 and down 0.7% from third-quarter 1983. For the full year, capital spending in 1983 totaled $9.32 billion, a decline of 17% from the year before. ☐

CMA urges little change in Superfund

Chemical Manufacturers Association chairman Louis Fernandez told a House subcommittee that CMA strongly supports reauthorization of the law governing cleanup of abandoned hazardous waste sites. As he pointed out, "Whether it's fair or not, the chemical industry is bearing the brunt of public unhappiness on this issue. So there is no one more eager than we to make it yesterday's environmental problem."

Fernandez urges that the reauthorization follow what he terms a "formula for a robust, workable Superfund law." This would include determining realistically what the Environmental Protection Agency's annual funding needs are, and providing for them; deriving these funds from industry taxes that are much more broadly based than provided for in the current law; imposing these taxes for a five-year period so that needs can be examined periodically; and re-enacting the law unchanged in all other respects, particularly in dealing with the issue of public compensation for injury separately from that of site cleanup.

Although the law authorizing cleanup of abandoned hazardous waste dump sites doesn't expire for another year, the House Energy Subcommittee on Commerce, Transportation & Tourism already is considering two bills—one Democratic, H.R. 4813, and one Republican, H.R. 4915—that would both greatly expand the fund and make several other changes in the Superfund law.

Neither quite follows Hernandez's formula. He says both present certain fundamental problems. However, he adds that H.R. 4915 has a more workable approach in that it recognizes the need for a five-year reauthorization, it leaves the question of joint and several liability to the courts, and it recognizes the need for Congress to address the question of entitlements for chronic diseases separate from the process of reauthorization of a waste-site cleanup law. H.R. 4813, by contrast, is open-ended and makes provision for all of the things that H.R. 4915 doesn't. ☐

House panel supports EPA R&D increase

Environmental Protection Agency Administrator William D. Ruckelshaus testified before the House Science & Technology Committee last week defending his fiscal 1985 budget proposal for research and development. The nearly 14% increase proposed for fiscal 1985 represents the first attempt to increase the R&D budget since 1981.

Rep. Don Fuqua's (D.-Fla.) committee praised Ruckelshaus' efforts to beef up research and expressed the hope that it was more than just a cosmetic improvement. As several committee members pointed out, the $278 million total for fiscal 1985 is still far less than the $350 million the agency requested for fiscal 1981. Ruckelshaus says that is kind of an apples and oranges comparison, pointing out that research priorities have changed since that time.

What is left of a large energy R&D budget, for instance, is a $34.4 million request for acid deposition work. Acid rain was probably the single most discussed issue at the hearing, as several Congressmen pointedly asked why nothing was being done. Ruckelshaus replied that there is as yet no consensus, either inside or outside Congress, about moving forward with controls to curb acid rain, and he cannot move until a consensus is reached. Until then, more research, particularly a large lake-monitoring program and the beginning of a forest-monitoring project, is planned.

Other areas of concern include alternatives to landfill disposal of hazardous wastes. EPA, it was said, has ordered the closing of nonapproved sites, and some locales are being left without any way to get rid of wastes. Ethylene dibromide was mentioned as well, as Congressmen wondered if the agency had adequate research capability to screen pesticides, both new and existing, for toxic effects.

Rep. George E. Brown Jr. (D.-Calif.) put some persepctive on the proceedings, reminding Ruckelshaus that the committee had been through these same discussions—acid rain, hazardous wastes, pesticides—10 years ago and that the research to solve them still had not been done. Although he added he would be willing to give EPA another 10 years, he would like to see better progress made. ☐

More Biotechnology Firms Making Money

The scene: A recent presentation to the New York Society of Security Analysts by the officers of a medium-sized biotechnology company. The president of the company is winding down the question and answer period.

President: Are there any other questions?

Analyst: Uh, when are you going to report some earnings?

President: (pause) No more questions? (pause) Well, thank you for coming.

A number of security analysts are calling 1984 the "year of transition" for U.S. biotechnology companies. They mean, in broad terms, that a sizable number of those companies will begin commercializing products this year. Specifically, they mean that many of them will begin reporting net income instead of net loss.

Analysts, whose laughter at what is now a stock biotechnology joke (see above) seems to be fading fast, would like that very much. They would like better guides than Ph.D. head counts, for instance, by which to separate the sheep from the goats. So they are taking some comfort from the biotechnology income statements for the final business quarter of 1983. There are more companies with profits than before.

For a group of 14 selected companies—representing a cross section of the genetic engineering, monoclonal antibodies, and biotechnology support (instrumentation and laboratory chemicals) segments—total revenues in the final quarter of calendar 1983 were some 70% higher than in the same period a year earlier. Even more significant, operating revenues (from product sales and contract research and development work) accounted for about 75% of the revenue in the 1983 period (for the nine firms that provided a revenue breakout). This means that firms are getting by less on interest earned by cash raised from public offerings, private placement, and other sources of capital, and more on their actual business activity.

There were some better reports on net income, as well. As a group, it is true, the companies still reported a large aggregate loss. But four of the firms had profits in the quarter, compared to just two the year before. That is a positive sign.

Biotechnology revenues were up in fourth-quarter 1983

	FOURTH-QUARTER 1983				Change from 1982	
	Operating revenue[a] ($ millions)	Total revenue ($ millions)	Operating revenue as % of total	Earnings[b] ($ millions)	Revenue	Earnings
Amgen	$0.90	$ 1.95	46%	$−0.97	596%	def
Applied Biosystems	na	4.27	na	0.74	231	1380%
Biogen	1.50	3.55	42	−6.08	20	def
California Biotechnology	na	1.82	na	0.08	487	nm
Centocor	na	2.39	na	−0.12	166	def
Cetus	8.05	10.63	76	0.29	75	nm
Collaborative Research	0.86	1.41	61	−0.99	21	def
Damon Biotech	0.42	1.09	39	−0.44	24	def
Genentech	na	13.46	90[c]	0.23	18	−87
Genex	na	4.70	na	−1.70	161	def
Molecular Genetics	1.63	1.94	84	−0.02	143	def
Monoclonal Antibodies	0.30	0.44	68	−1.00	144	def
Ribi ImmunoChem	0.11	0.18	61	−0.04	64	def
Vega Biotechnologies	na	0.73	na	−0.22	62	def

a Includes revenue from R&D contracts, product sales, and royalties, but excludes interest income. b Excludes extraordinary credits from federal income tax reductions for loss carry-forwards. c Revenue breakout was not public at press time, but company has estimated operating/total revenue ratio at 90%. def = deficit. na = not available. nm = not meaningful.

In the case of many of the firms with losing quarters, large revenue increases were overshadowed by increased commercialization costs: for product development, additions to marketing staffs and sales forces, construction of production facilities, and the like. Biogen's income, for instance, was cut sharply by the company's decision not to license completely its gamma interferon and interleukin-2, says chairman Walter Gilbert. This both eliminated license income and put the expense of clinical trials on Biogen.

"However, by reducing the involvement of licensees, we expect to generate higher revenues when these products reach the market," Gilbert explains.

The dilemma is one that most biotech firms have faced or will face eventually. Licensing provides ready cash, but it is not likely to generate sufficient income for long-term growth. Biotech chief executives know that marketing their own products is the way to better earnings. Genentech, for instance, hopes to have its first self-marketed product—human growth hormone—out this year.

"1984 is expected to be the final stage of our transition into a pharmaceutical company that not only develops and manufactures ethical drugs, but also markets products under its own label," comments Robert A. Swanson, Genentech president. "Depending on the timing of our human growth hormone marketing, this year may also see us begin to accelerate away from near-breakeven toward significantly greater earnings. Of course, 1984 would see only the modest beginnings of that trend."

David Webber, New York

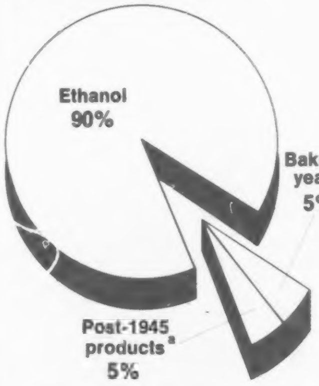
Problems Beset Carbohydrate Feedstocks

Petrochemical feedstocks are a well-known concept, but carbohydrates used as fermentation media also can be thought of as feedstocks. And just as with petrochemicals, there are problems of commodity products versus specialty media, lack of interchangeability, and dramatically low prices often set by the policies of government around the world.

Those are some of the conclusions of a new study on carbohydrate feedstocks for the fermentation industry by consultants Leo Hepner and Celia Male of L. Hepner & Associates in London.

Products made by fermentation are dominated by ethanol, which has been growing in importance over the past few years. That is particularly true as governments have emphasized and subsidized production of ethanol from native resources—for example, alcohol from cornstarch for formulating into gasohol. Ethanol, in fact, takes nearly 90% of carbohydrate feedstocks in the world market, or 27 million of a total 30 million metric tons of "as is" feedstocks. Fermentation of bakers' yeast demands another 5%, and what Hepner and Male term "post-1945" products the remainder.

Alcohol dominates feedstock production



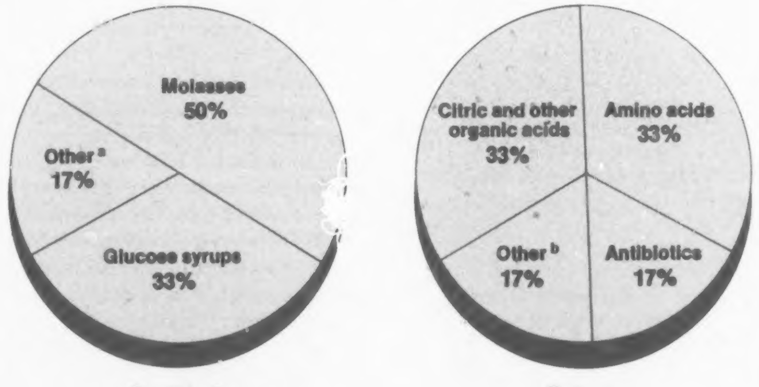
1983 total feedstock output = 30 million metric tons

[a] Includes antibiotics, citric acid, amino acids, enzymes, and vitamins.

It is that remainder of the market that the two consultants find most interesting—the now classic penicillin and other, more modern antibiotics, citric and other organic acids, amino acids, enzymes, vitamins, and others. The market for feedstocks for these products is now $300 million per year.

Molasses makes up half the carbohydrate feedstock for these modern specialties, glucose syrups a third, and all others—potato and corn starches, and lactose, among others—the remaining one sixth.

Feedstock use by post-1945 products is divided evenly



1983 total feedstock value = $300 million

[a] Includes cornstarch, farina, and lactose. [b] Includes vitamins and enzymes.

To some extent, companies that make fermentation products can switch among feedstocks. However, Hepner points out, in practice there are many difficulties. For one thing, microorganisms may be adapted or optimized for particular feedstocks. A change of feedstock could reduce productivity and lower the yields, thereby increasing costs until an optimum level is re-established. For many fermentations, a slow release of carbohydrate is important, so sugar would not be the most suitable substrate. And molasses—although a batch product that varies lot to lot, needing tight quality control and constant analysis—contains trace elements, vitamins, amino acids, and the like, which may play an important part in fermentation. If pure sugar were the feedstock, those extras would have to be added to the medium.

The goal, of course, is to maximize fermentation efficiency, and a system working well will be changed only after serious consideration. To some extent, the maximum is a biologically imposed restraint. For example, straight fermentation for primary metabolites probably reaches a maximum of about 30% conversion. For secondary metabolites, yields are much lower. Penicillin is probably about 35 g per L maximum, and some of the specialties, only about 1 g per L, if that.

Industry has shown increased attention over the past 10 years to waste products from fermentation. No matter how efficient the fermentation, "there is still slop in the tank afterwards," says Hepner. Companies no longer can discharge without pretreatment, and in some cases they have been denied expansion permits until they have suitable pretreatment plans.

Patricia Layman, London

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New general route to optically pure compounds
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Cover: Participative management meetings at Uniroyal

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- **Modified hemoglobin molecule releases oxygen more readily than does normal hemoglobin.** Page 6
- **China's first patent law goes into effect in April 1985.** Page 6
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Cover Story

Rise of participative management in chemical firms brings employees into problem-solving process. **Page 10**

Government Hit for Underfunding Academic Chemical Research

Costs of sophisticated instruments needed for research have been rising rapidly but agency funding assumptions lag far behind

George Pimentel brought his soapbox to Atlantic City early this month. His message: Write appropriate Congressional representatives and agency officials in Washington about the federal government's gross underfunding of academic chemical research.

Pimentel, professor of chemistry at the University of California, Berkeley, has for the past 18 months chaired a Committee to Survey Opportunities in the Chemical Sciences, a committee of the National Academy of Sciences/National Research Council. Last fall, committee findings were presented in Washington briefings, where committee members outlined three priority areas rich for exploitation: chemical reactivity, chemical catalysis, and chemistry of life processes (C&EN, Jan. 2, page 8).

Atlantic City, where the Pittsburgh Conference & Exposition on Analytical Chemistry & Applied Spectroscopy was under way, thus was an appropriate forum for Pimentel. Common to all three priority areas is a need for sophisticated state-of-the-art instrumental techniques—without which, the committee maintains, U.S. science will fall behind in areas crucial to the national well-being. In a theme symposium at the conference, Pimentel outlined the committee's findings. Then he presented his view on the extent of underfunding, noting that he and not the committee is responsible for the estimates.

C&EN staff photo

Pimentel: instrument needs are crucial

Prices of the higher-cost instruments, such as nuclear magnetic resonance spectrometers, have been increasing rapidly in recent years. "That's not greed on the part of the instrument people," Pimentel says, "that's performance. We're seeing that skyrocketing cost because these instruments are so very, very powerful." But, he says, the assumptions of the funding agencies in Washington on what it takes to equip a chemistry laboratory are more appropriate to the Bunsen-burner/test-tube age.

Pimentel says the National Science Foundation has, in his opinion, been in the van in recognizing the importance of instrumentation in chemistry and in trying to do something about it. In 1969, 1970, and 1971, about 8% of the NSF chemistry division budget was going into instrumentation in both departmental grants to universities and in dedicated grants embedded within individual project grants. That amount went up to 14 to 18% for a few years, and is now at 25%. The increase, Pimentel points out, has occurred even though the budget hasn't been burgeoning.

Needs, however, are another matter. Pimentel approaches this issue by looking at possible menus of instruments, and arrives at what he considers a package of key instruments—eight of them—costing almost $3 million. This package forms the basis for his attempt to estimate what the NSF departmental instrumentation budget should be.

Cost sharing is required, Pimentel says. Cost sharing, he notes, now runs in the neighborhood of 60% or so by NSF. The rest comes from the university department. But, he points out, university money is getting harder and harder to come by, and the point is being reached where university resources can't be strained any further. He thus proposes 80% as a more reasonable NSF share of costs.

Another point in arriving at a budget estimate is that the instruments must be operated and maintained over reasonable lifetimes of the instruments. From a variety of sources Pimentel arrived at what he considers a reasonable amount to provide cost-effective use of an instrument over a reasonable obsolescence time. He has settled on five years as an obsolescence time, for which, he says, the initial grant would carry the implication of support at 20% of the purchase price per year. This makes the cost of the instrument package $5 million.

"Now," says Pimentel, "the question is: How many instruments should we aspire to?" He suggests that 25 universities might on average receive a grant a year. Thus, over a six-year cycle, they might each have six of these instruments put into operation. Six years, he figures, is a reasonable cycle time, since if a university got, say, an NMR spectrometer in the first year, the odds are that by the end of six years the advance of techniques would be such that it would need another. Likewise, Pimentel suggests that it might be desirable to serve 50 universities every other year, and perhaps 75 every third year.

Thus, over a six-year cycle, for 150 universities "trying to keep at the frontiers of research," 450 instruments would be required. This need, Pimentel says, equates with 9.3 packages of instruments per year and defines an ultimate need of $47 million for the departmental instrumentation budget. The proposed NSF budget in this area for fiscal year 1985 is $13.5 million—a shortfall of $34 million.

Pimentel takes a similar approach for dedicated instruments—those for experiments in which a mass spectrometer, say, must be attached to the experiment in a way that prevents sharing or community use. His menu in this case calls for 14 instruments, with maintenance and operation at 20% per year, and with three years in the cycle. The result is $4.8 million per 14-instrument package.

These instruments, Pimentel says, are appropriate to programs like chemical physics, chemical dynamics, and structural and thermal chemistry. The number of grants in each of these areas is 180 per year. So with 540 grants per year and a budget for these programs of $41 million, the average grant size is $76,000. Pimentel notes that about 10% per year of the grant already goes into dedicated instrumentation, so the question is, what is needed above that?

With 540 grants per year, Pimentel says, at least the top 10% ought to get one of these dedicated instrument grants. That amounts to four packages per year. The present investment is $4.1 million. The cost of four packages per year is $19 million. Hence the shortfall is $15 million.

Instruments aren't all, Pimentel says. Grant size is also important. The NSF budget in fiscal year 1985, minus the instruments, provides about $68.7 million for grants in all of the chemistry division. There were about 800 grants in fiscal year 1984, and if the grant size were increased 6%—merely inflation—there would be about 860 grants in 1985. This leads to an average grant of about $80,000.

What will that $80,000 buy? Not much, says Pimentel, because it includes overhead. It will buy, he says, a postdoc, a couple of graduate students, one month of salary for the faculty member, and a little bit of services and supplies. "Now that's not much of a research effort, believe me," Pimentel says. And it results in academic researchers spending lots of time on grantsmanship, seeking multiple grants.

Pimentel suggests two other models, one based on four graduate students and one on six, with two months of salary for the principal investigator, and a more reasonable estimate of the amount of supplies it takes "to keep that number of people doing good science." These models lead to budget sizes of $145,000 and $195,000. If the top 25% of the grants were made at the level to support one postdoc and six graduate students, there would be a need for an additional $25 million in the budget. If the next 25% were funded with this model in mind, an additional $14 million would be needed. The shortfall, Pimentel says, is $38.7 million.

And that overall analysis is just for NSF. "The picture looks the same—I might even say worse—if you look at other agencies," he says.

"It's time," he emphasizes, "for the agencies that fund science to awaken to the importance of chemistry. There are very rich scientific opportunities before us. There are enormous potential societal gains. Instrument needs is one of the crucial dimensions." □

Commerce outlines Reagan technology policy

In 1980, Congress passed a piece of legislation called the Stevenson-Wydler Technological Innovation Act that was signed into law by President Carter. This act was designed to invigorate the future U.S. economy by providing a fully integrated technology policy within the government. Now, almost four years later, the Commerce Department has issued a report on how well that law was attended.

The act essentially made the Commerce Department the catalyst and

Many university-industry centers for industrial technology already have been established . . .

	Field	% funding by industry
Massachusetts Inst. of Technology	Processing of polymers	100%
Rensselaer Polytechnic	Applied polymers	80
Ohio State U	Welding	70
U of Massachusetts	Properties of polymers	75
U of Rhode Island	Robotics	75
North Carolina State U	Telecommunications	70
Rutgers U	Ceramics	70
Georgia Inst. of Technology	Materials handling	80
Worcester Polytechnic U	Automation technology	50
Texas A&M U	Hydrogen technology	50
Pennsylvania State U	Dielectrics	60

. . . and others are being planned

West Virginia U	Fluidized-bed combustion
U of Cincinnati	Digital processing
U of Wisconsin	Biotechnology
Northwestern U	Tribology
U of Arizona	Microcontamination control
Duke U/U of North Carolina	Biotechnology

steward of the new interagency thrust. Commerce was to establish an assistant secretariat for technology and innovation and form centers of industrial technology, along with a center for helping business get hold of promising inventions developed or owned by the federal government.

The agencies and their laboratories around the country were to try extra hard to transfer the fruits of their research and development programs to the private sector by setting up Offices of Research & Technology Applications (ORTAs).

In its report, Commerce says essentially that it is doing a good job in fashioning a Reagan Administration flavor to something that, after all, the Democrats put out. It says it kept the best Democratic ideas, threw out others, and added a lot of improvements, focusing on government antitrust, patent, procurement, regulatory, research and development, and tax policies as the primary means of increasing industrial innovation.

The report says the ORTAs are going great guns with staffs gradually becoming expert in targeting federally owned inventions for transfer to businesses. The keystone to all this is the proposed uniform federal patent policy that can assign to the whole private sector exclusive rights to develop and essentially own the fruits of taxpayers' investments. Up to now, only small businesses and universities have had free access to those inventions. The Reaganites think they now are on the brink of pulling it off through passage of the Uniform Patent Procedures Act (S. 2171) sponsored by Sen. Robert Dole (R.-Kan.).

The Administration also is pulling for the always controversial changes in antitrust policy through its proposed National Productivity & Innovation Act. The Commerce report gives the examples of collaborative groupings that are not violating antitrust regulations, such as Semiconductor Research Corp., Microelectronics & Computer Technology Corp., American Welding Technology Applications Center, and Control Data Corp.'s Research Limited Partnerships. "Under the Administration's proposal," it says, "so long as ventures do not aid price fixing (through, for example, exchange of information on prices or production levels), or reduce innovation (by, for example, a tacit agreement to underinvest in R&D), the ventures do not violate the antitrust laws."

What the Administration has not done is implement what was a key provision in the act—establishment of so-called Cooperative Generic Technology Centers. These were to focus on technological needs that were common to broad swaths of companies—areas such as polymer science and technology and welding. Reaganomics had a great deal of trouble with the idea that government should be paying for and doing the kind of development industry itself should do, so they scuttled the idea. Instead, the report says, industry has gone ahead and established its own centers, and the National Science Foundation's own program of providing seed funding for Centers for Industrial Technology through universities is moving along nicely.

Under that program, NSF totally funds startup of such centers, requiring the universities to attract total industry support after the two or three year incubation period. Each center received funding of between $500,000 and $1 million from anywhere between five and 30 firms.

What Commerce is most proud of is its Research & Development Limited Partnership Program that Stevenson-Wydler said nothing about. Commerce's assistant secretary for productivity, technology, and innovation, Bruce Merrifield, spends most of his time promoting the concept and providing advice to groups interested in forming such ventures.

So if the letter of Stevenson-Wydler has not been followed, at least the spirit has. At the same time, the act did finally give the Commerce Department a legislative mandate to forge working concepts of technology policy.

Wil Lepkowski, Washington

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PRODUCT OF ISE CHEMICALS INDUSTRIES CO., LTD. JAPAN
*Patent Pending

Nonflammable substitute for PCB introduced in U.K.

The toxic nature of polychlorinated biphenyls (PCBs) has led to rules against their use in electrical transformers. Since the first warnings of their potential environmental hazard, there has been a widespread effort to seek substitutes.

What is billed as "the world's first totally nonflammable insulating and coolant transformer fluid" has been launched in the U.K. Tradenamed Formel NF, it is the result of a five-year research and development effort by England's Electricity Council and ISC Chemicals of Avonmouth, near Bristol. "Its overwhelming advantage over fluids containing hydrogen is that it will not ignite in air, eliminating the risk of an explosion or fireball from a transformer under catastrophic fault conditions," the developers claim.

Formel NF is a mixture of four short-chain aliphatic halocarbons. ISC, which specializes in halogen chemistry, declines to identify the compounds apart from saying that they contain chlorine and fluorine, and that they do not contain hydrogen. Absence of hydrogen is important since tests show that its presence, even in amounts of less than 1% by weight, increases not only the risk of flaming, but also the tendency to yield corrosive byproducts that damage a transformer.

ISC does say, however, that the four components have been used individually for a number of years, mainly in nonelectrical applications, without any harm, noting that the new fluid "has an acceptable toxicity profile under all conditions of operation in transformers and switchgear." In contrast to PCBs, which persist in the environment for many years and can accumulate in the food chain, the Formel NF components degrade in the atmosphere and do not bioaccumulate, the developers say.

The U.K. Atomic Energy Authority's research establishment at Harwell, near Oxford, has conducted a detailed evaluation of Formel NF. The environmental safety group there carried out a comprehensive hazard assessment. The physicochemical unit sampled and analyzed the test fluids, as well as residues and vapors evolved during destructive tests. The nondestructive testing center measured the resulting temperatures using infrared techniques. "Comparative catastrophic tests show that the toxic products from decomposition of Formel NF are very significantly less [than for the other fluids], and do not constitute a serious hazard," it concludes.

The London Electricity Board began installing transformers containing Formel NF on its 11-kV system a year ago. Modification of the transformer design has since reduced the quantity of fluid in each to less than 300 L compared to 615 L originally.

The new fluid costs more than hydrocarbon insulating oils, "but a significant part of the extra cost can be offset by reduction in the number of radiators and winding design," the Electricity Council points out. "A heat exchanger in place of radiators will further significantly reduce the quantity of fluid. The outcome is a compact transformer having relatively small dimensions and a very low fluid content." □

Outlook hazy for employment in energy R&D

As a tool for planning for future manpower needs in the field of energy R&D, the Department of Energy's latest annual manpower report would seem of limited value. Its main conclusions are that energy R&D spending in the U.S. will increase somewhat through 1988, or else it will go down. Employment in these fields will increase slightly in 1984, but what it does through 1988 will depend on whether or not spending in these areas increases.

The problem in reaching firm conclusions about the state of energy R&D funding and employment in the U.S. is the difficulty in predicting what changes will occur in the

Chemistry, chemical engineering particularly hard hit by expected energy R&D employment changes

Employment field, number of positions	Projected change resulting from decreased government funding 1983-88	Projected change resulting from increased private funding 1983-88		Projected net change	
		Low estimate	High estimate	Low estimate	High estimate
Ph.D.					
Mathematics/computer science	−170	30	80	−140	−90
Physics/astronomy	−210	10	40	−200	−170
Chemistry	−325	150	450	−175	125
Earth, environmental, marine sciences	−125	100	300	−25	175
Chemical engineering	−250	125	375	−125	125
Petroleum engineering	−40	30	80	−10	40
B.S./M.S.					
Mathematics/computer science	−100	150	400	50	300
Physics/astronomy	−30	20	60	−10	30
Chemistry	−350	150	450	−200	100
Earth, environmental, marine sciences	−100	600	1650	500	1550
Chemical engineering	−350	300	850	−50	500
Petroleum engineering	−10	200	550	190	540

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private sector. DOE's 1984 budget has outlays for energy R&D pegged about 3% higher than 1983 levels, although this is only some 68% of the 1981 level. Through 1988 these levels are expected to decline slightly more.

Private sector growth estimates are less certain, and the DOE report considers two different predictions. One, from the National Science Foundation, predicts an increase in private energy R&D spending in 1984 of 6.8% followed by increases of 6.0% per year through 1988. The other, made by McGraw-Hill, expects an increase of 1.9% in 1984 and annual increases of 2.1% thereafter.

These uncertainties translate into a particularly uncertain picture for the next few years for chemists and chemical engineers working in energy R&D. Federal cuts are expected to mean the loss of 325 jobs in chemistry at the Ph.D. level and another 350 for bachelors and masters degree holders by 1988. Using the low-growth public sector model, only 150 jobs in each category can be expected to be added by nongovernment employers, for a total loss of some 375 jobs by 1988. Using the high-growth model, however, 450 new jobs will be created at each level by 1988, for a net overall increase of 225. Similarly, chemical engineers can expect to lose from government-supported R&D efforts 250 Ph.D.-level jobs and 350 masters- and bachelors-level jobs by 1988. Using NSF's model they may gain 1225 private-sector jobs at the two levels combined; by the McGraw-Hill model they would gain only 425 for a net loss of 175 jobs.

If the "real" growth in energy R&D jobs through 1988 is neither the high estimate nor the low one, but an average of the two, and degree trends at universities do not change, the report predicts that the supply of new chemists will be adequate for the job market. But chemical engineering Ph.D.s could be in short supply unless foreign nationals on temporary visas fill roughly 25% of the jobs for new graduates.

Copies of the report, "Energy-Related Manpower, 1983," (DOE/ER-0134/1), are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22161. ☐

French chemical industry finishes drastic restructuring
Page 22

APRIL 2, 1984

A1250-1 4/4/84

CHEMICAL & ENGINEERING NEWS

PROCESS CONTROL

Closer ties with process simulation and design

Page 7

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Cover: Control loop being tuned at custom graphics console. Photo courtesy of Fisher Controls International

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CHEMICAL & ENGINEERING NEWS

APRIL 2, 1984

News of the Week

- **UN observers confirm the use of chemical weapons on Iranian ground forces in Persian Gulf war. Page 4**
- **Polytechnic Institute of New York to offer master's program in imaging sciences and engineering. Page 5**
- **First bits of data on Spacelab 1 experiments unveiled. Page 5**
- **Racing car engine containing many plastic parts to debut in Connecticut race. Page 5**
- **Atlantic Richfield sells its polypropylene operations to Cosden Oil & Chemical. Page 6**
- **Crystallography technique may allow scientists to make movies of biological reactions. Page 6**

Business

1984 is a good year for the chlor-alkali industry but the long-term outlook is for slow growth, lower share of world output. **Page 18**

International Business

Restructuring of the French chemical industry is a fait accompli but so far it has not translated into profitability. **Page 22**

Government

General Accounting Office recommends a fixed allowance for indirect costs of federally funded university research. **Page 27**

Science

Potentiometric electrodes to measure antigen and antibody levels are being developed by University of Delaware chemists. **Page 32**

Major future advances in nuclear magnetic resonance techniques will grow out of more sophisticated experimental design. **Page 33**

Books

"Troubled Skies, Troubled Waters" discusses acid rain but avoids problems such as ignorance of its causes and effects. **Page 36**

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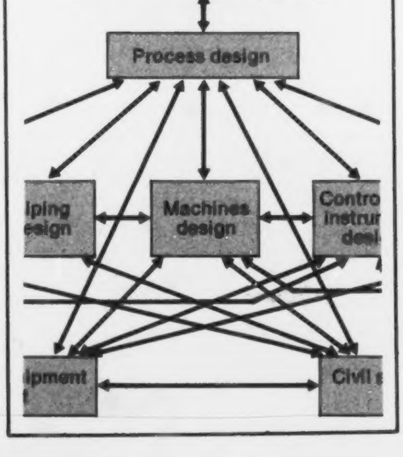


News Focus

Computerization is allowing further integration of chemical process control with simulation and design. Page 7

and piston pins, are made of its engineering resin Torlon, reinforced with carbon fibers. According to the company, Torlon is an injection-moldable thermoplastic polyamide-imide resin that can maintain structural integrity at temperatures up to 260 °C., under extreme load-bearing conditions.

The block, cylinder head, cam cover, and oil pan are made of Cycom, a composite made of woven Celion carbon fibers (from Celanese) impregnated with a thermosetting epoxy matrix resin (from American Cyanamid). Crankshaft, camshaft, combustion chambers, cylinder liners, piston heads, valves, and valve springs are metal. The engine, which contains 68 lb of metal, 60 lb of resins, and 40 lb of fiber reinforcement, is about 200 lb lighter than conventional engines of comparable size.

Polimotor president Matthew Holtzberg points out that reciprocating parts made of the light plastic generate lower inertial forces than do similar metal parts. The result, he claims, is 10% more available horsepower and a 12% cut in fuel use, compared to conventional engines.

Amoco and Polimotor note that the engine is still far too expensive for mass production; however, the current tests eventually could translate into improvements in passenger car engine design. □

Arco completes retreat from major polyolefins

Atlantic Richfield's shedding of major chemical operations now takes it virtually out of polyolefins. After recently bowing out of polyethylene, Arco now plans to leave polypropylene. The prospective buyer is Cosden Oil & Chemical, part of American Petrofina. For Cosden, a large producer of polystyrene, the move is a major diversification.

Cosden would be entering polypropylene production in the midst of a strong upturn in the thermoplastic. The rebound follows several years of poor business resulting from recession and overinvestment by new entries. The newcomers include Arco, which bought its plant from Diamond Shamrock in 1977 and then expanded it.

Cosden to start with 9% of polypropylene capacity

Millions of lb per year	Capacity
Cosden Oil & Chemical (American Petrofina)	470
Eastman Kodak	140
El Paso	370
Exxon	450
Gulf Oil	400
Himont	1320
Internorth	200
Phillips Petroleum	200
Shell Oil	600
Soltex Polymer	200
Standard Oil (Ind.)	550
U.S. Steel	515
TOTAL	5415

Sources: SRI International, industry estimates

Last week Arco and Cosden signed a letter of intent covering the polypropylene plant sale, which a Cosden spokesman says is expected to be closed in 90 days. The plant is at La Porte, Tex. Nameplate capacity after various expansions now is about 470 million lb per year.

The sale is subject to a definitive agreement, approval by the boards of directors of American Petrofina and Arco, and government agency approvals.

Cosden's move into polypropylene comes in a fast-rising market. In 1983, production topped 4.4 billion lb, up 28% from 1982, according to the Committee on Resin Statistics of the Society of the Plastics Industry. December 1983 production, the latest month for which data are available, was up 25% over December 1982.

The sale of its polypropylene continues a strategic about-face for Arco, which had built up strongly in polyolefins in the late 1970s. Earlier this year, Arco completed sale of its high- and low-density polyethylene plants at Port Arthur, Tex., to National Distillers.

Arco is now out of polyolefins except for a specialty polybutadiene plant. The reason for the current sale, says Arco Chemical vice president Bob G. Gower, is that the polypropylene unit is "not strategically critical" to the company, and the divestment will allow resources to be devoted to other projects. □

X-ray method may film biological reactions

Scientists at Cornell University have developed an x-ray crystallographic method that may someday allow them to make "movies" of biologically important reactions by piecing millisecond images together [*Science*, 223, 1423 (1984)].

Using a 70-year-old and largely neglected technique called Laue diffraction and the intense x-ray beams from the Cornell High Energy Synchrotron Source (CHESS), the researchers have acquired structural data from horse methemoglobin and bovine intestinal calcium binding protein in times as short as 450 milliseconds. Further improvements may shorten times at least to 10 milliseconds. Such times would be short enough to study molecular changes during recombination of hemoglobin with carbon monoxide after laser photolysis or release of calcium from the binding protein.

The method was worked out by biochemistry professor J. Keith Moffat, senior research associate Doletha Szebenyi, and CHESS operations manager Donald Bilderback. Their research was supported by the National Institutes of Health.

Laue diffraction uses a broad spectrum of x-rays rather than the monochromatic x-rays used in conventional single-crystal studies. Spots on photographic film are due to wavelength rather than angle of incidence, allowing use of more light and eliminating the need to rotate the crystal to collect light.

The Cornell team will try to improve the method by using three to seven times the current in the synchrotron as in the present work. It also will use what is called a wiggler rather than a bending magnet to intensify x-rays. Collection efficiency will be improved by using transmission mirrors instead of absorption filters. And x-rays will be passed through helium rather than air to eliminate absorption by air. □

Chlor-Alkalies Come Back Strong From Recession

Key Chemicals

Demand, prices are up again for chlorine, caustic soda, and soda ash, but long-term outlook is slower growth than in recent years

Bruce F. Greek, C&EN Houston

The chlor-alkali industry staged a major comeback during 1983. It likely will continue to improve this year, but it could be a long time getting back to historical record levels of production and profitability.

A strong recovery for polyvinyl chloride last year gave chlorine the lead in both production upturn and price improvement over the other two major chlor-alkalies, caustic soda and soda ash. Caustic soda followed as the year ended and soda ash got on the bandwagon just recently.

Unfortunately, the recovery occurred in two steps for the chlor-alkalies as it did for most other products. First, demand rose substantially. Then prices followed. For some months, these products were sold at prices well below current ones, even though production then was just slightly lower than it is now.

For example, chlorine production rose 8.5% in 1983 and likely will grow 4 to 5% this year. The value of chlorine produced, which reflects both increased physical volume and higher selling prices, climbed about 18% in 1983. This year the value could be up 75% over last year because fall 1983 price increases and more recent ones will apply for the whole year.

Production of caustic soda, chlorine's coproduct, also likely will rise 4% or more this year. Like chlorine, the big gain in demand for caustic stems from chemicals manufacture, which accounts for about half of caustic's market. List price of caustic is presently about $240 per ton and deep discounting seems to have abated.

Prices in a demand downturn fall more quickly than they rise in a recovery. So these products didn't and probably won't get all the income so badly needed at a critical time. This situation seems almost unavoidable in the future when another recession could bring growth to a halt.

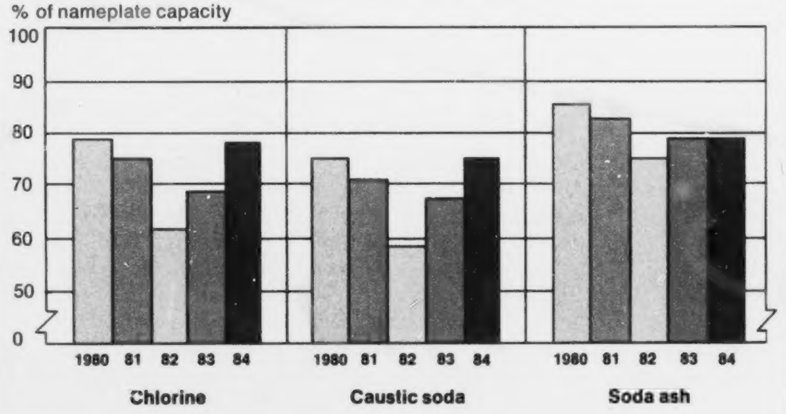
The long-term outlook for the chlor-alkali industry is for lower growth. Growth in 1984 of 4 to 5% for chlorine and caustic soda and 2% for soda ash could be viewed as good years for these products. Based on an analysis of the chlor-alkali industry by Consulting Resources, Roger Shamel, president of the company, forecasts long-term growth for chlorine and caustic soda at 1 to 2% per year and for soda ash 2 to 3% a year. This slow growth means a continuation of the loss of share of production by the U.S., now at about 30% of world production, according to Shamel.

This continuing decline in U.S. share of production could be accelerated by more plant closings. Except for soda ash, capacity declined in both 1982 and 1983, and it seems quite certain to decrease in 1984 and beyond.

No expansions of capacity, including that to make or recover soda ash, seem likely for a long time in the face of current demand forecasts. Investment money that does go to chlor-alkalies will be earmarked to improve process efficiencies, a major concern as the result of an order of magnitude increase in energy costs in the past decade.

For details of the near-term outlook for these major chlor-alkalies, see the following pages.

Capacity use will remain below 80% in 1984



Sources: Industry and C&EN estimates, Chlorine Institute, Bureau of Mines

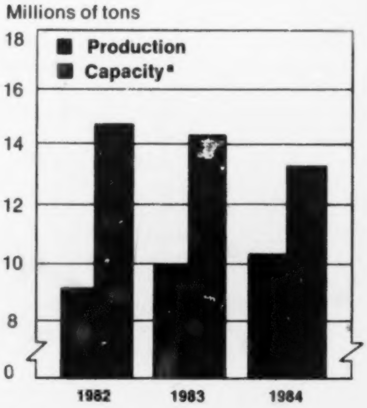
Key Chemicals

Cl_2

Chlorine

- ***Production recovering***
- ***Capacity down***
- ***Prices up strongly***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Electrolysis of NaCl brine; recovery from hydrochloric acid; coproduct with metals; electrolysis of KCl brine

MAJOR DERIVATIVES (U.S.)

Ethylene dichloride 20%, other C_2 derivatives 10%, C_1 derivatives 10%

MAJOR END USES (U.S.)

Organic chemicals and plastics 65%, pulp and paper 15%

FOREIGN TRADE

Exports and imports—100,000 to 200,000 tons per year

PRICES

List prices $195 per ton and higher

COMMERCIAL VALUE

$2 billion for production, 1984

Currently U.S. producers of chlorine are enjoying a recovery from the recession of 1982. Gains in production forecast for this year, however, will not be so good as they were in 1983. But producers who stuck it out during the severe downturn may begin to show some profit this year as both selling prices and production are up substantially.

In 1984 production of chlorine likely will increase at least 4% to 10.4 million tons from last year's level. Output in 1983 was up 8.7% from the recent historical low of 9.2 million tons in 1982.

Surprises in chlorine production also might occur during 1984. The unexpected strength in the economy could mean a greater than previously forecast consumption of chlorine. As a result, production could rise 5 to 6% over 1983 to as high as 10.6 million tons.

Still, the robust production forecast for this year will be well below the record set in 1979 when production was nearly 12.3 million tons. Obviously, some years will be needed before output exceeds this record if growth rates hold at 4 to 5% annually. If the economy sags again, however, holding average growth to about 3% annually, then the 1979 record might not be exceeded before 1990.

Even as production of chlorine rises, capacity to make it falls and probably will continue to fall. At the beginning of this year, capacity was estimated at about 13.4 million tons a year, down 1 million tons from the estimate a year earlier and down 1.4 million tons at the beginning of 1982.

Clearly, the recession took a heavy toll of chlorine capacity, almost all of it in the electrolysis of sodium chloride brine. What happened is that plants using this process that had been shut down were scrapped under the economic pressure of the recession. Large investments in old plants would have been needed to make process efficiencies high enough to compete with new plants built during the most recent round of capacity expansions in the late 1970s and early 1980s. At the low selling prices of chlorine that existed during 1982 and early 1983, such investments could not be justified.

Possibly such investments can't be justified even now, considering the substantially higher prices being received for chlorine. As a result, some additional obsolete chlorine capacity may be shut down and eventually scrapped. Chances therefore are good that the industry's capacity will be lower at the beginning of next year than it is now.

Because of the shut-down capacity, producers' estimates vary on the actual operating rate for chlorine plants. For example, if all of the capacity estimated to be operable at the beginning of 1984 were utilized to produce 10.4 million tons of chlorine this year, the operating rate would be about 78%. That is well up from the rate calculated the same way for 1982—14.8 million tons of available capacity as the year opened and a total production for the year of 9.2 million tons—for a rate of 62%.

During 1982 and 1983, some capacity was scrapped and quite a bit was shut down, but not scrapped. Even now as much as 1.5 million tons of capacity could be shut down, because industry sources put the rate of the plants operating at between 85 and 90%.

The current strength in chlorine production and in operating rates because of the capacity reduction has considerably strengthened chlorine prices. List prices are up $50 per ton from last year's levels. Selling prices probably are up even more as a result of reductions in discounts off list prices.

Prices of chlorine derivatives are up, too, indicating that chlorine users are able to pass on much of the chlorine price increases. Higher prices for these derivatives, such as polyvinyl chloride, are the result of a healthy recovery in demand. As might be expected, some in the industry say that prices for PVC have increased about 50%, whereas chlorine prices have risen 33%.

Increased demand, higher prices, generally more efficient plant operations, and improved profits will combine to make 1984 a much better year for chlorine producers than last year. No plans for capacity expansions are being made for certain, but some investment will go for membrane conversions to gain more efficiency. This year won't be so good as 1979, but it will definitely be better than the past three.

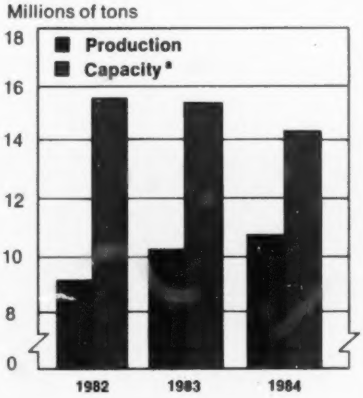
Key Chemicals

NaOH

Caustic soda

- ***Production rebounding***
- ***Capacity down***
- ***Prices turning up***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Electrolysis of NaCl brine

MAJOR DERIVATIVES (U.S.)

None

MAJOR END USES (U.S.)

Chemical manufacture 50%, pulp and paper 20%, soap and detergents 5%

FOREIGN TRADE

Exports—down to less than 1 million tons in 1984, imports—rising to more than 400,000 tons

PRICES

List prices mostly $240 per ton; deep discounting now easing

COMMERCIAL VALUE

$2.2 billion for production, 1984

In a reversal of form from recent years, caustic soda (sodium hydroxide) is following the fortunes of chlorine, its coproduct in the electrolysis of sodium chloride brine. Both products are experiencing a continuing rise in production as demands improve with the economic recovery. As is the case for chlorine, the major gain in caustic demand comes from manufacture of chemicals, the natural result of the economic recovery.

Production of caustic in 1984 likely will be up at least 4% over production in 1983 to 10.7 million tons. If chlorine demand remains as strong as it has been in recent weeks and the rising demand for caustic continues, caustic output also could surprise forecasters. Finished caustic production also could be up 6 to 7% over 1983 production, possibly topping 11 million tons in 1984.

This production level, of course, still would be considerably below 1979's record output of caustic of about 12.8 million tons. At these forecast growth rates, it would take until about 1990 to match the 1979 record, assuming recessions do not interrupt the growth curve.

Caustic's price has improved and is currently about $240 per ton. Heavy discounting also has eased.

The industry's capacity to make caustic soda dropped roughly the same amount as chlorine capacity last year, or some 1 million tons, after a 400,000-ton drop in 1982. Now caustic capacity is about 14.3 million tons a year, perhaps a bit less as decisions have been made in the past two months to scrap plants that had been shut down previously. Again, as in the case of chlorine, caustic capacity probably will be lower at the end of this year than it was at the beginning.

Despite the close relationship of chlorine and caustic soda, small amounts of chlorine are made in other chemical processes, for example, as the coproduct of making caustic potash (potassium hydroxide), as the product of oxidation of hydrochloric acid, and as a by-product of the cracking of ethylene dichloride to make vinyl chloride. The only commercial route to caustic, on the other hand, is by electrolysis of sodium chloride brine.

However, not all caustic produced by this electrolysis process becomes reportable production. Depending on current economics, some quantities of caustic are not "finished" or concentrated from the cell liquor to commercial specifications but used in dilute form for alkalizing purposes in chemical processes. Such use further upsets production estimates based on stoichiometric production ratios of chlorine to caustic.

The nonchemical manufacturing uses of caustic also are sharing in the recovery. Pulp and paper manufacture, the largest such market with a 20% share of caustic demand, has been increasing its use for caustic even in the face of growing substitution of plastic films for paper. However, this use will not be a large gainer for caustic long-term.

The next largest outlet for U.S.-produced caustic is the export market. In 1983, exports rose slightly over 1982 but are still well down from 1981 when they amounted to about 1.3 million tons. For 1984, exports may decline again in the face of foreign competition.

As the worldwide economic recovery moves ahead, however, exports might hold steady or rise slightly as foreign producers of caustic find that their own markets are improving so much that they have less for export. New capacity for the electrolysis process in various countries plus economic changes makes exports difficult to forecast.

Imports, on the other hand, are expected to rise this year, probably topping 400,000 tons (they may have exceeded that quantity in 1983). Competition and the strong value of the dollar aid imports.

Other significant outlets for caustic are moving slowly, if at all. None will have much of an effect on caustic demand, one way or another.

For this year then, caustic soda's fortunes will tag along with those of chlorine. If its demand improvement lags that of chlorine by about six months, that could keep it going a bit longer if chlorine demand should sag late in the year. On balance, caustic will contribute considerably to better profits this year, but probably to a smaller share than will chlorine.

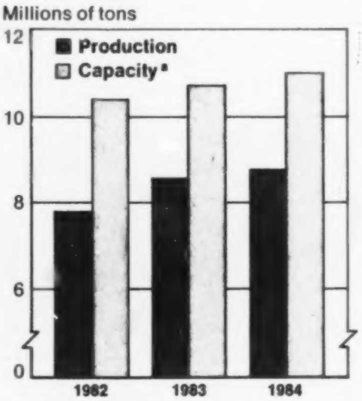
Key Chemicals

Na_2CO_3

Soda ash

- ***Production at record***
- ***Capacity excessive***
- ***Price discounts cut***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Recovered from trona ore or brine; synthesized from salt and limestone using ammonia

MAJOR END USES (U.S.)

Glass (containers and flat) 55%, chemical manufacture 20%, pulp and paper 5%, soap and detergents 5%

FOREIGN TRADE

Exports—easing to about 1.5 million tons in 1984, imports—negligible

PRICES

List price $84 per ton at Wyoming mines; discounts about $11

COMMERCIAL VALUE

$650 million for production, 1984

Soda ash producers are looking at a different year than are chlorine and caustic soda producers.

This year, production of soda ash may rise slightly, possibly 1 to 2%, signaling an end to the substantial demand recovery fueled by exports in 1983. The latest chlor-alkali price action, that of a reduction in temporary voluntary allowances (TVA) on list prices for soda ash, will be less helpful to profit margins than will be those initiated earlier for chlorine and caustic soda.

Soda ash demand and, in turn, production during 1983 depended heavily on the export market. Exports ballooned last year to more than 1.6 million tons, or some 19% of U.S. production. They were up about 500,000 tons over 1982 exports.

The recovery in the U.S. economy accounted for the remaining 200,000 tons of production growth for this chemical. With the strong surge and competitive pressures on the container market from plastics abating following the recovery, U.S. consumption of soda ash may grow slightly or even decline a bit in 1984.

Production, too, is a bit uncertain at this time, with forecasts for this year ranging from slight increases to declines. Optimists believe exports will rise again by a small amount, and that the slight rise in consumption will result from continued strong demand for flat glass by the housing and automobile industries and delays in the forecast growth of plastic containers at the expense of glass containers, primarily because of technical problems in making the containers as economically as expected. Glass currently accounts for more than half of the soda ash consumed.

Both the chemical and paper industry demand for soda ash will at least match that of 1983, with strong possibilities of an increased 100,000 to 200,000 tons going to these uses if caustic soda costs keep rising. These markets rank next to glass in importance among uses of soda ash.

As for exports, although the big increase in shipments of soda ash to China may be over for the near term, increased exports to a variety of other countries could add another 100,000 to 200,000 tons to demand for U.S.-produced soda ash.

Pessimists forecast that U.S. consumption of soda ash will slip 3 to 5% this year, or about 200,000 tons. This is because of the inroads of plastics into container markets, as well as a slowing of the rate of the economic recovery.

Exports of soda ash may hold at about 1.5 million tons through aggressive selling even as exports to China slow some. The worst-case scenario calls for a decline in production of about 200,000 tons this year. More likely would be a match of 1983 production with some small increase in inventories.

A more reasonable forecast for this year may be a 2% increase in soda ash production to about 8.7 million tons. This gain would be significantly lower than what is expected for chlorine and caustic soda.

Nameplate capacity to produce soda ash totals about 11 million tons a year of both natural and synthetic. No capacity expansions are in the works and even debottlenecking probably will be minor during 1984. Operation of this capacity will run at a 79% average for 1984. This rate will be a bit higher than a couple of years ago, but it still will not be at a level that could mean high plant efficiency and good profitability.

Slightly higher production, no new capacity, and considerable reduction in inventories during much of 1983 are factors that led to the reduction of the $15-per-ton TVA disclosed in early March. The reductions in the TVA vary a bit with location. Most important, however, is that the net list price for bulk material at the Green River, Wyo., location goes to $73 per ton. This price increase and possibilities of others later in the year have made soda ash producers, who have been struggling with limited profitability for some time, a bit more optimistic.

Although the big jump in demand may be over for now, soda ash fortunes improved in 1983 and seem to be continuing to improve as the first quarter of 1984 ends. If glass container consumption of soda ash doesn't fall too fast, a stabler demand and price situation could be beginning.

University Research Costing Changes Urged

Grant agencies and universities alike have been worried the past few years about the rapidly increasing proportion of research funds used to pay for expenses other than direct costs of research. These indirect research costs have attracted Congress' attention as well, and now the General Accounting Office has issued a long-delayed report that recommends, among other things, a fixed allowance for indirect costs at large universities.

In preparing the report, GAO looked mostly at grants made in 1981 and 1982 by the National Institutes of Health, which distributes about half the federal funds for health research and development and is considered the example for the rest of the federal programs. The investigative agency took a detailed look at 82 of the 200 or so universities that receive large amounts of NIH grants (more than $3 million annually) and tried to ascertain why each asked for the overhead that it did. These schools received $601 million from NIH in 1982, of which 32% was for indirect costs.

Specifically, GAO determined that, at NIH, indirect costs had risen from an average of 21% of cost of extramural research grants to 30% in the decade 1972–82. These funds are supposed to pay for university administration expenses, maintenance expenses, operation of facilities, and depreciation and use allowances. The rate of indirect costs as a proportion of the research grant is determined by each university for its specific circumstances according to instructions set forth in the Office of Management & Budget Circular A-21.

Proportion of NIH grants going to indirect costs has risen steadily

$ Thousands	Total grant costs	Total indirect costs	% of indirect costs to total costs
1972	$ 808,108	$166,243	20.6%
1973	799,665	185,587	23.2
1974	985,738	240,191	24.4
1975	1,000,496	258,938	25.9
1976	1,444,630	386,164	26.7
1977	1,320,302	359,140	27.2
1978	1,529,066	416,093	27.2
1979	1,844,001	512,279	27.8
1980	2,050,074	586,306	28.6
1981	2,224,138	655,143	29.5
1982	2,300,534	689,855	30.0

Source: General Accounting Office

In its report, GAO probed what the Department of Health & Human Services (of which NIH is a part) was doing to slow the growth of indirect charges, how well HHS was documenting the requests for increased indirect cost payments, and how often audits were done at universities and how these were used.

GAO had a problem when it came to verifying just why universities asked for large—more than 10%—increases in indirect costs. Much of the time there was no written explanation in the file for such a rise. And the largest area of increase was for departmental administration, an area in which it is impossible to segregate teaching from research from administration performed by the scientist. Estimates for time spent on different tasks given HHS negotiators by university administrators are very subjective and difficult to question therefore, and HHS usually accepts the request if it follows the OMB guidelines.

One way to verify the need for the indirect costs requested is to perform an audit of the university's system. However, that's not done very frequently. During a five-and-a-half-year period, GAO found that only 50 indirect cost audits had been performed by HHS on educational institutions. It also was determined that HHS was able to do only about half the audits requested by its grants negotiators. The department says it needs to devote more of its audit resources to the bigger programs like social security, medicare, and medicaid.

But where audits were done, significant amounts of indirect costs were not accepted. GAO says of 41 audits, which discussed $515 million in indirect expenses, the auditors refused to accept $64 million, or 12.5% of the request. The unwritten assumption is that if more audits could be performed, the indirect costs problem would be reduced considerably.

Of course, universities are correct in trying to recover their expenses for government-sponsored research. One reason for the increases was the inflation of the late 1970s, and higher administrative costs because of federally mandated social programs like affirmative action, pension benefits, and equal opportunity employment. Universities also have increased the sophistication of accounting methods trying to maximize their indirect cost requests.

To try to bring these costs down, the Administration proposed in 1982 that HHS cut indirect cost requests 10% across the board, but Congress refused to allow such a move. GAO is recommending that OMB revise Circular A-21 to establish a fixed allowance for indirect costs at large universities. This would cover all indirect expenses and could possibly vary from university to university depending on circumstances. HHS already has made some effort to control these costs, GAO reports. This includes asking grantees to justify increases in indirect costs in writing and a move to having more audits done by nonfederal auditing agencies.

The fixed rate concept already has some acceptance at other agencies and is being studied at HHS for NIH grants. And it is one of the savings suggestions made by the Grace Commission in its review of federal spending practices. Still, there is resistance to major changes in the system in Congress, where indirect-cost recovery is viewed by some as an important source of income for financially troubled universities. ☐

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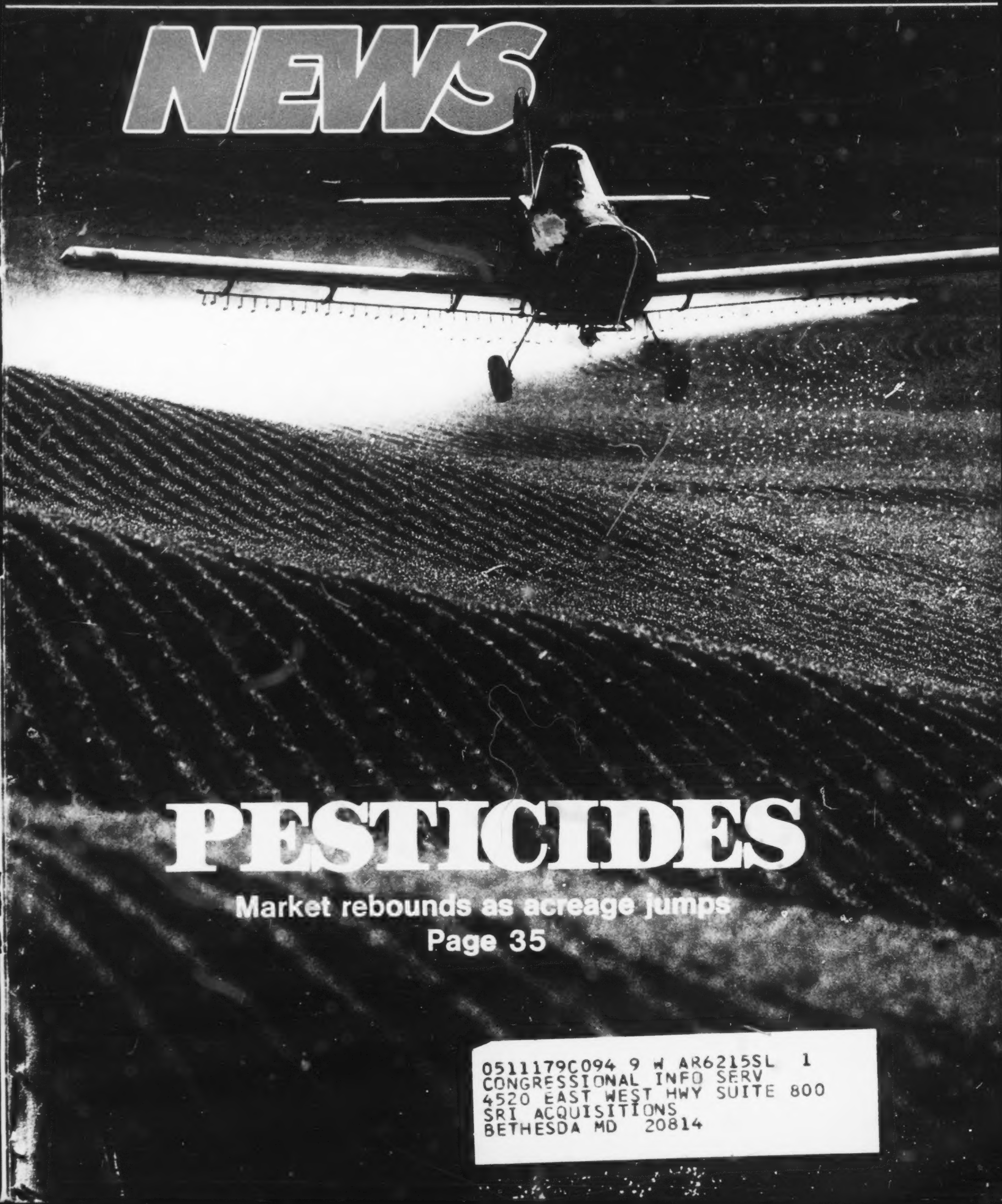
APRIL 9, 1984

CHEMICAL & ENGINEERING NEWS



PESTICIDES

Market rebounds as acreage jumps

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Cover: Aerial spraying of Du Pont herbicide
on wheat crop in Washington state

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CHEMICAL & ENGINEERING NEWS

APRIL 9, 1984

News of the Week

- **AAAS analysis of federal R&D budget frets over vulnerability to cuts.** **Page 6**
- **President calls for rebuilding of chemical armaments as a deterrent to their use.** **Page 7**
- **DEC's new minicomputer offers chemists faster calculations, larger capacity.** **Page 7**
- **Inability of AIDS sufferers to produce gamma interferon may be clue to treatment.** **Page 7**

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Business

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Government

EPA cost-benefit study of effects on health and the environment of eliminating lead additives in gasoline predicts savings of nearly a quarter of a billion dollars by 1988. **Page 18**

Science

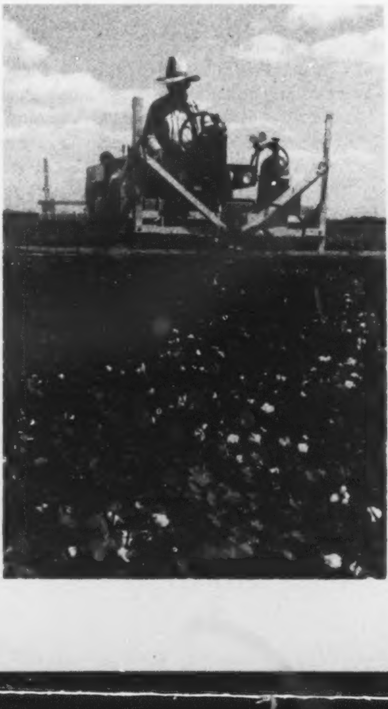
Theories concerning oxygen toxicity and role of proteins called superoxide dismutases are crux of scientific debate. **Page 20**

Education

The Institute for Chemical Education, set up at the University of Wisconsin, Madison, aims to develop creative ideas to convey chemical knowledge, improve interdisciplinary links. **Page 28**

ACS News

***Chemical Abstracts* publishes its 10 millionth abstract** only 13 years after the 5 millionth appeared; in contrast it took almost 32 years for *CA* to produce the first million. **Page 61**



Pesticide Report

Pesticide makers expect a good year—crop acreage will improve and farm prices rise from last year's low. **Page 35**

AAAS R & D ANALYSIS: Federal funding vulnerable to cuts

The American Association for the Advancement of Science's ninth annual report on R&D, the focal point of a recent colloquium, is a gloomy document. Although admitting that the Administration's proposed budget is strong for R&D, the report says that this is overshadowed by the need for drastic actions to reduce the deficit.

The report reiterates the by-now-familiar points that the big R&D increase is almost entirely on the military side, whereas the nondefense R&D budget increases only about as much as inflation; that there are larger increases for research in the physical sciences and engineering than for biological and medical sciences; and that programs in areas considered to be private-sector responsibilities are again recommended for drastic cuts or termination.

And it concludes that the President's budget, instead of being a plan for dealing with the problems of the nation, is rather "a statement of the problem, with the answers left up in the air—to be found in bipartisan negotiations with Congress, unilateral Congressional actions, or a new Presidential initiative sometime after the elections. However it comes, the answer will result in a new budget, markedly different from the present fiscal 1985 budget. Some combination of tax increases, other new revenues, and major surgery on the expenditure side seems inevitable."

The report points out that R&D will be in an exposed position for deficit-control budget cutting: defense R&D because it is a "controllable" part of the largest, single "controllable" class of expenditures in the budget, and nondefense R&D because it represents such a large "controllable" part (20%) of total expenditures for nondefense programs.

At the colloquium, Presidential Science Adviser George A. Keyworth II took exception to the report's assumption that the R&D priorities in the budget "will be thrown out the window during an inevitable orgy of budget cutting down the road." And he questioned what he sees as the report's implication that changes in research funding priorities are inherently bad.

Keyworth contends that most of the increases in defense R&D come from development costs associated with the modernization of the nation's strategic forces—an action needed to restore strength that was eroded during the previous decade. On the other hand, he says, the flat curve in civilian R&D reflects two countervailing trends—a steady drop in development and a steady rise in basic research, which has grown from the smallest fraction of nondefense R&D to the largest. Keyworth also points out that since 1981, support for university R&D, which had been essentially flat, has grown 26% in real terms.

The section of the report that deals specifically with chemistry, prepared by Le-Nhung McLeland and Annette T. Rosenblum of the American Chemical Society's Office of Public Affairs, is generally upbeat, finding that the proposed budget is favorable for basic research in chemistry, particularly academic research. Among the highlights is that for the first time in years the National Science Foundation's chemistry division expects the number of grants awarded to increase by 50 and the average award amount by almost $8000.

Copies of the report are available from the AAAS Sales Office, 1515 Massachusetts Ave., N.W., Washington, D.C. 20005. The price is $10. □

Funding for programs supporting chemistry up almost 11%

$ Millions	1985[a]	1984[a]	1983[b]	% change 1984–85
NSF	**$206.3**	**$180.7**	**$162.2**	**14.2%**
Chemistry	92.1	80.0	67.6	15.1
Materials	66.5	57.5	46.9	15.8
Other	47.7	43.2	47.7	10.4
DOD[c]	**153.8**	**144.8**	**139.9**	**6.2**
Materials	87.5	82.8	81.0	5.7
Chemistry	66.3	62.0	58.9	6.9
EPA	**132.9**	**110.7**	**108.1**	**20.0**
Extramural R&D	100.1	81.9	71.4	22.2
In-house R&D	32.8	28.8	36.7	13.9
Energy	**104.4**	**96.9**	**90.6**	**7.7**
Chemical sciences	80.9	75.5	70.0	7.1
Materials chemistry	14.8	13.4	12.3	10.4
Nuclear sciences— heavy element chemistry	5.1	4.7	4.4	8.5
Geochemistry	3.6	3.3	3.9	9.1
NBS	**40.6**	**42.5**	**41.2**	**−4.5**
TOTAL	**$638.0**	**$575.6**	**$542.0**	**10.8%**

a Estimate. b Actual. c Funds classified under budget category "6.1." Note: Chemistry support by NIH not included because of the difficulty of breaking out the actual amounts.

Additives Widen Refiners' Options in Making Gasolines

Oxygenated compounds along with metal antiknocks, toluene, and processing methods complicate cost estimating for refiners

Petroleum refiners making gasolines are looking harder than ever at their costs. Many more options than a decade ago are now available to refiners and blenders of gasolines to use in making the various grades of gasoline.

These options range from conventional processing—for example, catalytic cracking and reforming—to use of lead alkyls, oxygenated hydrocarbons, and other hydrocarbons to gain desired octane values. George H. Unzelman, technical director of Ethyl Corp.'s petroleum chemicals division, and George W. Michalski, manager of refinery technology of the division, assessed these options for refiners at the 82nd annual meeting of the National Petroleum Refiners Association held recently in San Antonio, Tex.

Refiners use various kinds of linear programing models to evaluate octane costs under varying conditions of crude oil acquisition costs, processing costs, additives, and overheads. The gasoline pool remains the critical money-maker in most refineries. The antiknock additives are the last increment of flexibility in blending gasolines to specifications and controlling costs.

Lead alkyls remain the lowest-cost way of increasing octane value, but their use is becoming more and more limited by government regulations. Another additive, manganese in the form of methylcyclopentadienyl manganese tricarbonyl, also has been used for some time.

Currently growing in importance as additives to obtain desired octane values are the oxygenated hydrocarbons—such as alcohols, methyl *tert*-butyl ether, and blends of these materials—and toluene. However, various Clean Air Act and Environmental Protection Agency regulations limit the amount of oxygenates or oxygen allowed in gasolines. Much controversy has developed over the effect of oxygenates in gasolines on drivability, their compatibility with fuel system components, and the like.

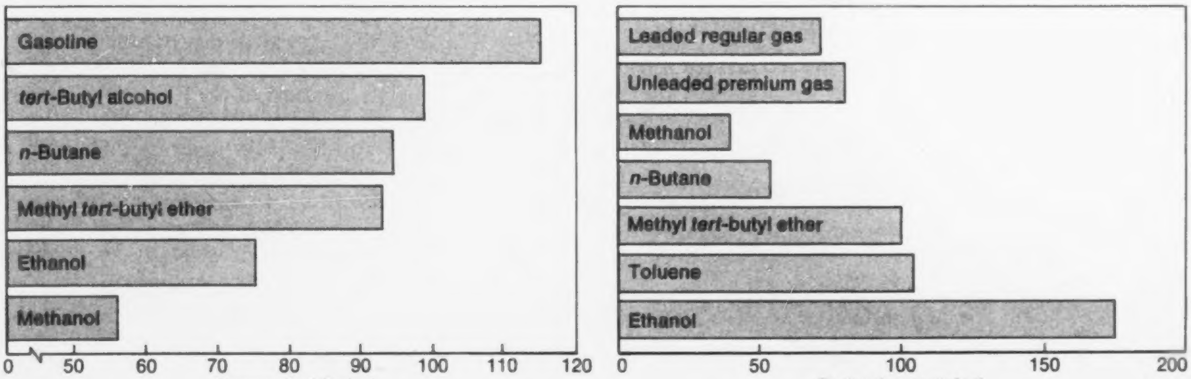
Of the various oxygenates, methyl *tert*-butyl ether (MTBE) has blending characteristics close to those of the hydrocarbons in gasolines. For this reason, it is the only oxygenate generally accepted for blending and subsequent transport of the gasoline through pipelines, Unzelman and Michalski point out.

Use of fuel-grade ethanol in gasoline has increased rapidly. Ethyl estimates that more than 300 million gal of fuel-grade ethanol were used in 1983. However, this amount, equivalent to about 20,000 barrels a day, is about 0.3% of the more than 6.2 million bbl a day of gasoline sold.

Methanol, currently in excess supply, causing its price to be down to barely profitable levels for most producers, can be used in leaded gasolines. But so far EPA has not granted waivers for its use in un-

Many octane enhancers trail gasoline in energy . . .

. . . and some are more expensive per gallon than gasoline



Source: Ethyl Corp.

Cost of using octane boosters varies widely

	Volume %	Cents ONB[a]		
		Unleaded regular	Unleaded premium	Leaded regular
Ethanol, at 176¢/gal	10%	155.4¢	177.6¢	201.8¢
with 5¢/gal subsidy	10	79.8	88.2	105.9[b]
with 10¢/gal subsidy	10	4.3	−1.2	10.0[b]
Ethanol at 176¢/gal	5	173.9	195.0	231.4
tert-Butyl alcohol	16	81.2	114.2	66.1
Methyl *tert*-butyl ether				
at 100¢/gal	11	45.1	49.0	41.7
at 100¢/gal	4	48.8	52.6	45.2
Toluene at 105¢/gal	4	48.6	53.7	44.0
Methanol at 40¢/gal	5	−19.0	−17.2	−29.2
at 70¢/gal	5	35.8	35.7	51.6

a Octane Number Barrel, or raising one barrel of gasoline's octane value by one number. b Assumes that gasohol subsidy applies to leaded gasoline. **Note:** Negative numbers show cost saving over pure gasoline. **Source:** Ethyl Corp.

leaded gasolines without a cosolvent. Cosolvents are used with methanol to minimize water-methanol phase separation from the rest of the hydrocarbons in gasolines. *tert*-Butyl alcohol is by far the most common cosolvent and has been used alone in a blend with minor amounts of compounds as an additive.

Of the commonly used additives to increase octane values of gasolines, lead alkyls cost the least, toluene and MTBE the most. Calculations for estimating cost of octane improvement are more complex when using blending agents such as the oxygenates or toluene, according to Ethyl. Important factors are volume, vapor pressure, and finished cost. The volume of a blending agent to improve octane value can be relatively large if compared to an antiknock. Vapor pressure requirements can mean that adding a volatile blending agent such as methanol can cause less n-butane to be added to a gasoline with a credit for less n-butane used but a penalty for loss of the relatively high octane value of n-butane. Subsidies in the form of tax exemptions of 5 to 116 cents per gal of gasoline containing 10% ethanol are the equivalent of 50 cents to $1.60 per gal credit. □

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EPA Study Backs Cut in Lead Use in Gas

Recently the Environmental Protection Agency's Office of Policy Analysis quietly released for public comment a study that concluded the U.S. could reap health and environmental benefits totaling nearly a quarter of a billion dollars or more if all or nearly all lead were removed from gasoline by 1988.

Except perhaps for fluoridation of water and creationism, nothing raises the dander of affected groups faster than the issue of lead. And EPA's study quickly elicited both accolades and brickbats. Former Carter EPA official William Drayton, who is now chairman of an environmental health coalition called the American Environmental Safety Council, says this study is "one of the highest quality staff studies I've seen." Vice chairman of the board of Ethyl Corp. Lawrence E. Blanchard Jr. says that a "juvenile and simplistic approach is now being taken by EPA to justify their efforts to further reduce lead in gasoline." Ethyl is the nation's largest producer of tetraethyllead, used to boost the octane rating of gasoline.

Unfortunately for Ethyl, the usual stumbling block within the Reagan Administration for pro-environmental regulatory changes agrees with Drayton. Says the Office of Management & Budget's administrator for information and regulatory affairs Christopher C. DeMuth: EPA's economic analysis "is a model of how regulatory issues in the health area ought to be approached." He challenges Ethyl to "go beyond denunciations and tell us where the study is wrong."

Ethyl will have to act swiftly because EPA soon is expected to propose a revised lead-in-gasoline regulation under the mantle of the Clean Air Act. Several weeks ago EPA Administrator William D. Ruckelshaus said his agency was considering a rule banning all lead use in gasoline by 1988. More likely, however, is a regulation lowering the lead content of gasoline from the current level of 1.1 g per gal to 0.1 g per gal by 1988.

Lead use level in gasoline was last lowered in 1982. The catalyst for that action was studies conducted by the Centers for Disease Control and the National Center for Health Statistics. These showed a direct correlation between lowered lead use in gasoline and lowered blood lead levels in all U.S. population sectors, but especially in the most sensitive group, children. The 1982 standard was estimated to lower blood lead levels below CDC's "undue lead absorption" level of 30 µg per deciliter. Above this level, there is damage to the kidneys, liver, reproductive system, blood-forming elements, basic cellular metabolism, and brain functions.

Since 1982, clinical studies have indicated adverse health effects at blood lead levels below CDC's current lead toxicity standard. And EPA has found that its 1982 lead phasedown campaign has been short-circuited by misfueling.

Use of leaded gasoline in catalyst-equipped vehicles poisons the catalysts and results in higher tailpipe emissions of conventional air pollutants, and more frequent tuneups, oil changes, and exhaust-system replacements. In fact, EPA's low-lead option (0.1 g per gal) would lead to maintenance benefits of $660 million, and a ban on lead would lead to maintenance savings of $755 million by 1988. Eliminating misfueling would reduce the damage caused by conventional pollutants $404 million under either option. The low-lead option would reduce medical care costs $41 million and cognitive damage (including the loss of several IQ points) $184 million, whereas an all-out lead ban would reduce these costs $43 million and $193 million, respectively.

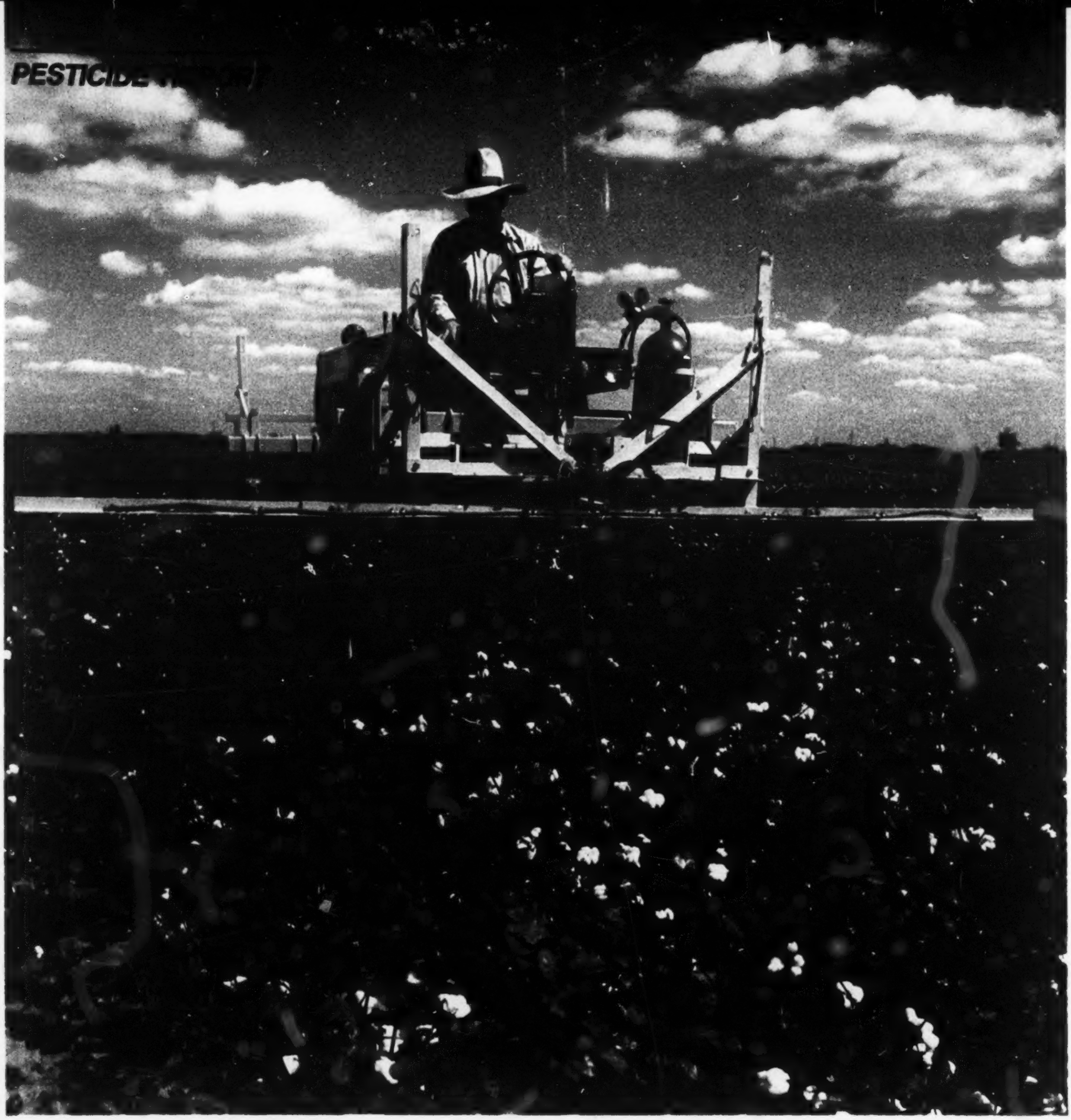
On the cost side, the low-lead option would cost refiners $503 million, and the cost of the no-lead option would be $691 million in 1988. EPA could not predict future marketing strategies and, therefore, was unable to estimate the change in gasoline price to consumers.

Lois Ember, Washington

EPA's cost-benefit study at a glance

	Low-lead option[a]	All unleaded[b]
Total costs ($ millions, 1983)	$503	$691 + nonmonetized valve damage
Total benefits ($ millions, 1983)	$1,289 + nonmonetized health benefits	$1,395 + nonmonetized health benefits
Net benefits ($ millions, 1983)	$786 + nonmonetized health benefits	$704 + nonmonetized health benefits
Reductions in emissions (thousands of metric ions)		
Lead	33	36
Hydrocarbons	314	314
Carbon monoxide	2,202	2,202
Nitrogen oxides	130	130
Ozone (formed as result of HC and NO_x emissions)	1.5% reduction	1.5% reduction
Total reductions in number of children at risk of various adverse health effects	6,251,000	6,584,000

[a] 0.10 g of lead per gallon of gasoline available by 1988 to vehicles requiring some lead; assumes no misfueling.
[b] All lead in gasoline banned by 1988. Source: EPA's Office of Policy Analysis.



Pesticides Head for Recovery

William J. Storck, C&EN New York

In the U.S. today companies' fortunes can rise and fall on pesticide sales. For instance, much of Monsanto's profits over the past couple of years have come from its agricultural chemical operations. And Stauffer Chemical ran into trouble last year as the company's pesticide sales were adversely affected by government programs.

Last year was indeed trouble for pesticides. However, this year certainly promises much better times, as crop acreage improves and farm prices pick up.

In some ways, pesticides are still coming into their own. There is probably more research being done in this relatively small segment of the chemical industry than in any other with the exception of pharmaceuticals. No longer are the products crude poisons that could kill the plant as well as the pest. Instead, they are fairly narrow, specific acting control substances for weeds, insects, and other pests. And they are much more active compounds than in the past, with applications sometimes measured in ounces per acre rather than in pounds or tens of pounds as they were just a decade ago.

In fact, this increased specific ac-

Home and garden pesticides are a steady market

Pesticides for home and garden use were not immune from problems last year. However, the problems were mostly weather related, having nothing to do with government programs and little with the recession. In fact, home and garden pesticides are counterrecessionary since, as economic times get hard, people tend to increase vegetable gardening to raise more of their own food.

The problem last year was the weather, which was bad for gardening practically all across the country. Thus, shipments of home and garden pesticides dropped precipitously. But, producers say, this year likely will see a return to the traditional 4%-per-year growth for this small but important segment of the market. In fact, they say, in areas of the country where home gardens already are started there is spectacular growth in pesticide use over last year.

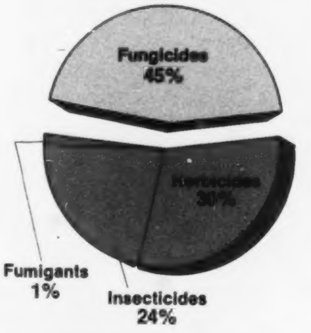
The market research firm Predicasts estimates that in 1982 about 97 million lb of herbicides, insecticides, fungicides, and fumigants valued at about $377 million were sold for home and garden uses.

Industry sources say that there are a number of reasons for the relatively slow but sure growth in the use of home and garden pesticides. Among these are the fact that more people are joining the gardening ranks because they believe they can save money and produce better vegetables at home than they can get in the store. And, they say, it's fun.

There is an irony in the garden use of pesticides, one industry spokesman says. It is, by and large, the people who believe that chemicals generally are in some way harmful who plant gardens, and yet, to protect their investment, they themselves are big users of pesticides.

Another reason for the growth is that people are upgrading the value of their properties by improving lawns and planting trees, shrubs, and flower gardens. This is a relatively inexpensive way to add value to a home. And finally, the people who don't own homes with lawns, but rather apartments or condominiums, are using more pesticides, primarily because of the increase in houseplants.

Fungicides are biggest-volume home pesticide



Total 1983 volume = 97 million lb

Sources: Predicasts, C&EN estimates

However, the future is not all rosy for the home and garden pesticide market. Predicasts forecasts that the decreased construction of single family homes will cause the home and garden market to level off after about 1987. And it sees little growth between 1987 and 1995. Growth is tied more to new housing starts than to product development.

There are problems, too, in simply developing new products. W. L. Shewry Jr., merchandising manager for Chevron Chemical's Ortho consumer products division, says that most of the products for home and garden use are developed by the large agricultural chemical companies. And these companies opt for registrations for the large cash crops first. This tends to cut off new product development for the home market because the cost of testing for registration is just too high for the small volumes involved. "There are no big developments in the consumer market," Shewry says.

There is, however, quite extensive toxicity testing in the home and garden market. Ortho, for example, maintains a toxicology laboratory and six testing stations. In addition, some testing is done in conjunction with the companies that have developed the product.

Another product restriction is that home owners tend to apply more pesticide than is called for. Thus, if the product is not safe at at least two to three times the recommended levels, companies just won't sell it.

As an example of the necessary lack of innovation in the industry, the largest-selling herbicide is probably the old standby, 2,4-D. And the largest-selling insecticides are Sevin, malathion, and diazinon—three traditional insect killers.

Producers say that eventually there will be new products, but because of the lack of commitment on the part of the agricultural chemical producers, the lead time before a product gets to the home and garden market is very long. Some of the new products introduced for agriculture today, one producer says, will not make it to the home and garden market until probably the turn of the century.

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tivity is the primary reason for the decline in production in the pesticides industry. According to figures from the U.S. International Trade Commission, production of pesticides in the U.S. declined 21% between 1973 and 1982 to 1.11 billion lb. Because the new generation of pesticides is more active, not so much is needed on crops. Demand for pesticides tells much the same story, falling 16% to 1.15 billion lb in 1982.

The new generation of pesticides also is higher priced. During that same period between 1973 and 1982, the value per pound of pesticides rose almost 200% to $3.87. And, unlike production, the value per pound did not deline during the poor season of 1983, but stayed at its 1982 level. The result is that the value of pesticide sales during the decade increased 144% to $4.43 billion in 1982, according to ITC.

Last year, however, brought a halt to many of the favorable statistics counted on by pesticide manufacturers. Estimates are that production and demand skidded about 13 to 15% from 1982 levels and the value of those shipments was down about the same amount, as prices

Monsanto Agricultural Products Co. technician runs portion of residue tests required for registering new pesticides with government

remained flat with year-earlier levels.

There were several reasons for the slide. The first and probably most talked about was the government's Payment-In-Kind crop set-aside program. Under this program, planted crop acres were down about 14% to 255 million acres in 1983 from their 1982 level, according to Department of Agriculture figures. And two of the largest crops for pesticides—corn and cotton—had reductions in plantings of more than 25%. Even soybeans, the second largest crop in the U.S. behind corn, and exempt from the PIK program, saw an 11% reduction in crop acreage.

The weather also worked against pesticides last year. Some parts of the country had extremely cold, wet springs, delaying the planting season. This was followed by drought in the Midwest and South, which cut both herbicide and insecticide use through the summer.

Finally, the strength of the dollar compared with foreign currencies served to stifle exports of pesticides. Pesticide exports rose only 1.8% last year to a value of $1.29 billion from their 1982 level. This compares with an average annual growth rate over the past decade of a little more than 13% per year.

In a sense, exports are crucial to the fortunes of pesticide producers. They can take up to 50% of production in some areas and generally provide a buffer against economic downturns and vagaries in the weather in the U.S. And there is a large trade surplus in pesticides, with exports more than a billion dollars larger than imports in 1983.

This year, however, likely will be different, and pesticide demand may come close to matching that of 1982. The government's PIK program has been lifted, although there is still a set-aside program for corn. Producers say, therefore, if the weather cooperates it probably will be a normal year for pesticide use.

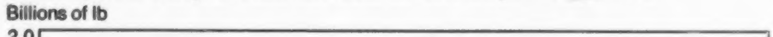
Farmers certainly are cooperating to make it a normal year for pesticide producers. USDA forecasts that crop plantings will be up sharply in 1984 from 1983. According to the government, corn acreage will rise 36% to 81.8 million acres this year. Cotton also will recover its loss, climbing 35% to 20.8 million acres from its level last year. USDA also says that soybean acreage will be up about 3% and wheat plantings will climb about 7.5%.

If USDA is right, even exports will get back on track, rising 9% to 218 million lb of active ingredients of fungicides, herbicides, and insecticides compared to 1983.

Though producers forecast an increase in total pesticides production in 1984, the government says that production of farm pesticides probably will decline in 1984 about 10% to 709 million lb. The reason for this is a large inventory carry-over caused by the poor season last year. According to the government figures, the inventory carry-over at the end of 1983 amounted to about 48% of that year's production.

The drop in production will result, of course, in a decline in capacity utilization. USDA says that capacity use for all pesticides will decline to about 47% in 1984 from 54% last year. As recently as 1982, pesticide plants had been operating at 80% of capacity. According to the government data, insecticide plants will be the worst off, running at about 35% of capacity, up from 33% last year. Herbicide operations will run at 54%, down from 66% in 1983. And fungicide plants will be going at 76%, up from 71%.

Pesticides output has drifted down in past decade



Sources: Department of Agriculture, C&EN estimates

Herbicides begin recovery from PIK program, other problems

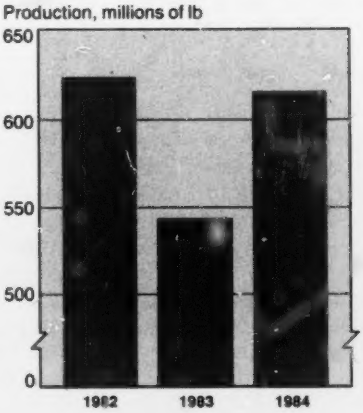
1983 was not a particularly good year for producers of herbicides. After a fairly steady rise in the value of herbicides shipments for more than a decade, sales suddenly dropped off.

The reasons for the fall were fairly obvious and to some extent expected. The government's payment-in-kind (PIK) program, which took a lot of agricultural acreage out of production, combined with a strong dollar, which to some extent throttled exports of herbicides, to play havoc with herbicide sales. Sales also were hurt by the recession and lower farm income. If all of this weren't enough, the weather conspired against the herbicide makers, giving them low rainfall in many parts of the country. And as one sales manager said, "If there is no rain, the weeds don't grow."

The PIK program was particularly hard on producers of herbicides for corn and cotton. These were two primary large crops included in the program. Soybeans were exempt from the program so that herbicides used on this crop did not suffer from the government policy.

Producers estimate that all of the problems taken together cut herbicide sales volume 13 to 15% last year to about 542 million lb from the 1982 level. The value of those sales was down 11 to 12%, since there was little price inflation in herbicides in 1983.

This year producers expect herbicides to recover about 90% of their losses as much of the government's PIK program ends. However, there is still a corn set-aside program, and herbicide producers are betting that participation in this program will be fairly heavy. It is still too early to tell, because farmers do not have to sign up for the program until May. And the feeling is that most will wait until the last moment before making their decision. Financial penalties for withdrawing from the program once the farmer has signed up for it are fairly heavy.



Even though intentions for planting in most crops are up from last year, herbicide producers do not think plantings, at least in corn and soybeans, the two largest crops, will get back to 1982 levels. In 1982, farmers planted about 82 million acres of corn and about 70 million acres of soybeans. This year plantings of each of these crops still will be 2 million to 3 million acres below 1982 plantings.

Like most pesticides, herbicide inventories this year are slim. One producer goes so far as to say that stocks are in the best shape they have ever been in. There has been a trend to lower inventories at the dealer level over the past few years, as the high cost of money makes dealers cautious about just how much inventory they want to carry. Manufacturers say that inventories also can be kept lower because the distribution chain has been streamlined, allowing for faster delivery of product to the dealers.

Ultimately, however, this trend has forced the carrying of inventories back to the manufacturers' level, a situation that they say they do not mind very much. "It's still a receivable to us, no matter where it is," one sales manager says. Some herbicide makers have even gone so far as to let out product on consignment. In other words, the manufacturer owns the product until it is sold by the dealer, even if it is in the dealer's warehouse.

Prices for herbicides are expected to be pretty firm this year given the tight inventory situation and the forecasts for increased planting. Last year, the Department of Agriculture says, herbicide prices were down about 4% from the year before, but it blames this on the continuing erosion of the price of atrazine and the much ballyhooed price cut on Lilly's Treflan, which manufacturers say was a market aberration. They say that Lilly lowered the price simply because its patent on the product will soon expire.

Thus, compared with last year, 1984 is going to be a good one for herbicide producers. Still, it probably won't be much better than average.

Thus, the year may be good enough that producers will at least recover what they lost during 1983, although they won't be back to 1981 levels as yet. Producers forecast that herbicides will recover their losses, and insecticides may well do better than they did in 1982.

Demand for miticides, a product category sometimes classified with insecticides, also will bounce back in 1984. Miticide producers insist that their products differ from insecticides because mites are arachnids rather than insects and thus have a different morphology. The morphological differences between mites and insects are great enough that mites quickly develop resistance to insecticides. Hence the need for miticides.

Miticide sales suffered last year along with those of other pesticides, because acreage was down for field crops. Although the largest use for miticides is in fruit trees, which were not included in the government PIK program, the decline in field crop acreage did hurt, since cotton and corn make up a significant portion of the market for miticides.

Miticide producers expect the value of their products to increase about 4 to 5% annually over the next five years. This growth is slowed somewhat by older, first-generation products that are almost of a commodity class. However, producers say that the increase in the value could be much greater if the Environmental Protection Agency initiates regulatory action against Rohm & Haas' Kelthane, one of these first-generation miticides that is coming under the gun because of its close relationship to DDT. If this product is removed, makers say, growers will

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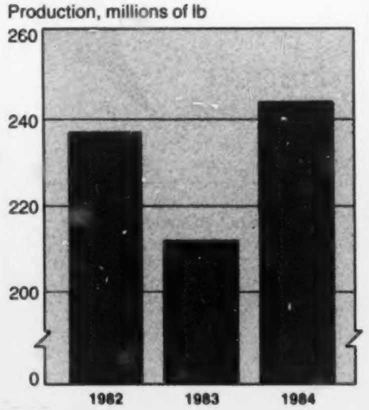
Insecticides' fortunes likely will improve this year



Like practically everything else in the agricultural chemical market, insecticides were hit hard by government acreage set-aside programs in 1983.

The crop that hit insecticides hardest last year was cotton, which is also the crop that uses the largest amounts of insecticides. Corn, soybean, and wheat uses of insecticides also were off from the previous year.

About the only good news in 1983 was prices. In spite of the decreased demand for insecticides, the Department of Agriculture says that insecticide prices were about 8% ahead of their 1982 levels.

Like herbicides, insecticides last year also were hurt by the drought in the Midwest and Southeast. The combination of the government's payment-in-kind program and the drought was "drastic" in terms of the insecticide market, according to one producer. As a result, pesticide shipments dropped about 11% last year to about 213 million lb from their 1982 level. Increased prices helped, however, so that the value of shipments was off only about 3% compared with the year before.

This year, though, promises to be different. The Department of Agriculture is forecasting that cotton acreage will be up about 35% to 10.8 million acres from the year-earlier level. This still will be, however, below the 11.4 million acres of cotton planted in 1982. Add to this the large gains in corn acreage and the potential is there for a strong rebound from last year's depressed levels.

Early forecasts from the government call for insecticide production to be up about 10% over last year, but producers are now saying that it may increase more than that.

Producers also say that insecticide inventories, like those for other pesticides, are in good shape. At least they are lower than they were a year ago. Until just recently, however, agricultural insecticides had not started to move from the dealer to the farmer.

Prices this year appear flat, though there is some variation between products. The biggest effect on prices seems to be a huge cut by Shell on its pyrethroid insecticides.

Industry sources say that this price cut by Shell amounted to 25% or more. According to these sources and to industry analysts, Shell lost market share on its pyrethroids last year, and with some new products being introduced by other manufacturers, the company cut the price to regain the lost share of market. Shell declined to talk to C&EN about its insecticide operations.

Exports of insecticides this year are expected to be about the same as in 1983. Exports are a significant part of the business and can account for as much as 50% of production. However, exports of insecticides, like exports of most products, are being hurt by the strong dollar. Insecticide imports, at about 6% of production or less, are not a significant factor in the market.

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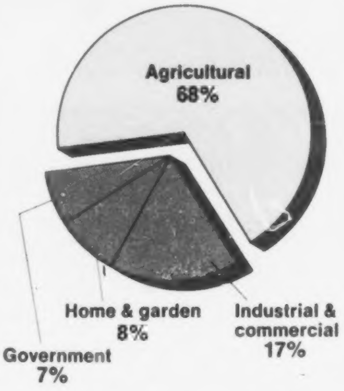
have to resort to the use of more expensive products.

Another pesticide category that is feeling heat from government regulation is fumigants, which also are expected to recover what they lost last year. However, this is a rather high-volume, low-value area, and one of its leading products, ethylene dibromide, is in the process of being phased out of agricultural uses by EPA (C&EN, Oct. 10, 1983, page 4). According to USDA, the loss of EDB as a soil fumigant will increase nematode control costs and could result in crop losses for some fruit and vegetable producers. The government also says that there are no

Agricultural uses dominate pesticide market



Total 1983 consumption = 1.11 billion lb

Sources: Predicasts, C&EN estimates

readily available alternatives for EDB for quarantine uses. EDB is used for quarantine treatment of fruits and vegetables to prevent the spread of fruit flies.

The other soil conditioners that are expected to do well this year are fungicides. Fungicides producers were hit last year because PIK affected the seed treating of corn. But, by and large, fungicide demand did not seem to suffer so much as some other areas of pesticides. It is growing about 5% per year as more intensive farming is increasing. And farmers also are aware that plant diseases are yield limiting.

The government is predicting only a 2% increase in fungicide production in 1984, but this is largely because of a 23% larger inventory carry-over at the end of 1983 than at the end of 1982. Demand for fungicides probably will be up about 6% this year over 1983. And exports, which can amount to more than one third of production, also are expected to climb about 6%.

This may be the pattern for fungicides for the long run. Predicasts, a Cleveland-based business information and market research firm, says that through 1995, the quantity of shipments of fungicides is expected to grow at about 2.1% per year. However, the firm says that the value of those shipments should grow at about 7.7% per year, reaching $13 billion in 1995. The slowdown in shipments volume, it says, will be the result of a continuation of the development of more concentrated formulations and improved application techniques that will reduce poundage requirements. Predicasts says also that government restrictions on the use of certain commodity toxicants will reduce consumption.

From 1984 through 1995, Predicasts says that prices will grow at an average annual rate of about 5.5%, reflecting higher raw material prices and an industry trend to shift the product mix to higher performance and higher value-added products.

Predicasts also says that U.S. pesticide producers will find their best growth abroad. According to the firm, increasing food production in the developing countries, inadequate foreign pesticide supply, and continued U.S. dominance in pesti-

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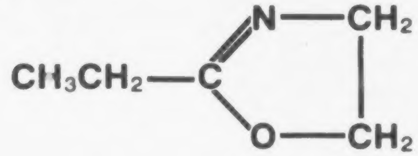

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Reform bill for regulating pesticides unlikely in 1984

Congress has been trying for well over two years to enact major reforms in the Federal Insecticide, Fungicide & Rodenticide Act, which gives the Environmental Protection Agency its authority to regulate pesticides. So far it has enacted only a simple one-year extension to Sept. 30, 1984.

Part of the problem is the wide-ranging nature of the reforms under consideration. Though they have been strongly endorsed by a coalition of environmental, health, labor, and consumer groups, the reforms have been vigorously opposed by at least 33 farm, business, chemical, and pesticide manufacturing groups. EPA isn't too happy with the proposals either.

The two bills, H.R. 3818 and S. 1774, would set deadlines for retesting pesticides that were approved for use before stricter cancer and genetic mutation tests were required; severely limit special state or local emergency uses of pesticides that have not cleared all of EPA's registration requirements; require that all applicators of restricted-use pesticides be certified; and require EPA to show that a pesticide does not endanger human health before approving its use. The last provision essentially would do away with the agency's ability to use risk/benefit analysis in its pesticide approval process, a procedure that has been strongly endorsed by EPA Administrator William D. Ruckelshaus.

Ruckelshaus recently told the House Agriculture's Subcommittee on Department Operations, Research & Foreign Operations, which last year began marking up H.R. 3818, that what are needed are administrative changes, not legislation. He also said that he believes additional public input is essential for formation of a responsible agency position. To that end he has formed a pesticide advisory panel "to probe the advantages and disadvantages of different legislative and administrative alternatives."

Areas which need to be approached by administrative action include: data quality, improving the registration review process, emergency exemptions from FIFRA, and the need to protect groundwater. Ruckelshaus already has taken steps to increase the number of EPA staffers auditing pesticide test data, and to require private testing laboratories to meet general quality control standards. He also is reviewing the need to ban certain pesticides in areas where they threaten groundwater.

In addition, EPA's newest enforcement policy document outlines a number of priorities for FIFRA. The priorities to be addressed include use problems that EPA and the states have agreed to track; submission of false data for EPA for pesticide registration, and label or formulation violations. In general, the document says that 75% of the office of pesticide programs' inspection resources will be allocated to use problems and 25% to product-related problems. Overall, the strategy reflects EPA's current policy of putting more emphasis on state control programs.

Ruckelshaus' actions, plus the fact that this is an election year (Congress won't want to stay in session too long), probably means that no major reform bill will be enacted this year. The Senate Agriculture Committee last year committed itself to hearings on the reform bill in return for its backers' support of the one-year extension. However, action past that is unlikely. What is likely is another simple six-month or one-year extension of FIFRA, with the more troublesome issues left for the 99th Congress.

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cide technology will boost exports to about 836 million lb valued at $5.3 billion in 1995 from about 391 million lb in 1982.

The pesticide industry in the U.S. is one of diversity. Estimates are that more than 400 firms produce pesticides; 25 of these, however, account for more than 80% of pesticide sales. In terms of specific compounds, the industry is much more concentrated. Only a few firms may dominate a particular market, such as postemergent herbicides for soybeans.

Further, entry into these markets may be barred effectively to new producers because of farmers' buying habits. The perceived effective-

Continued on page 54

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ness of a particular pesticide by the farmer is extremely important, producers say. Since pests may reduce the farmer's income significantly if unchecked, the average farmer is loath to switch from a particular, well-known compound to a less-well-known one.

Further compounding the problem of entry into the pesticide market is the enormous cost of developing pesticides. Estimates are that to develop a single commercial herbicide, 22,000 substances have to be found and investigated. Then after the substance has been developed and its effectiveness proved, it has to go through safety testing for EPA. Thus, the process can take a lot of time and a lot of money. Du Pont estimates that it costs about $45 million in R&D to bring a new pesticide product to market. This compares with about $3 million in the 1950s.

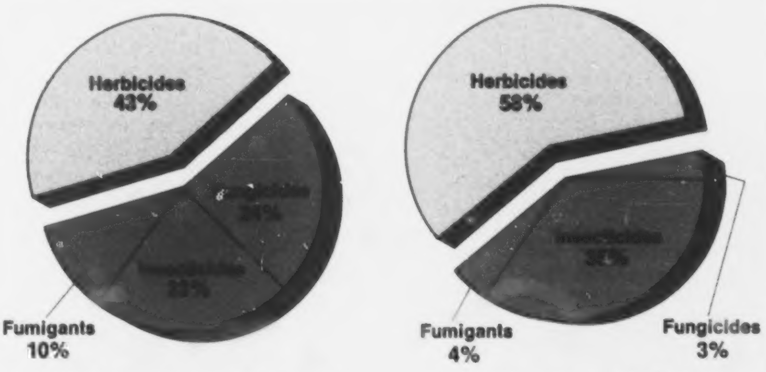
Because of the huge amount of time and money involved, pesticide producers for years have been trying to get changes in the patent laws, allowing them to patent their products later than at the point of discovery. This would allow producers to have longer than seven to nine years of the 17-year patent life in which to recoup their investments.

To counter the problem, producers are taking out use patents, which can describe the method of application or how the product may be used. In this way they can add longer patent life to the product.

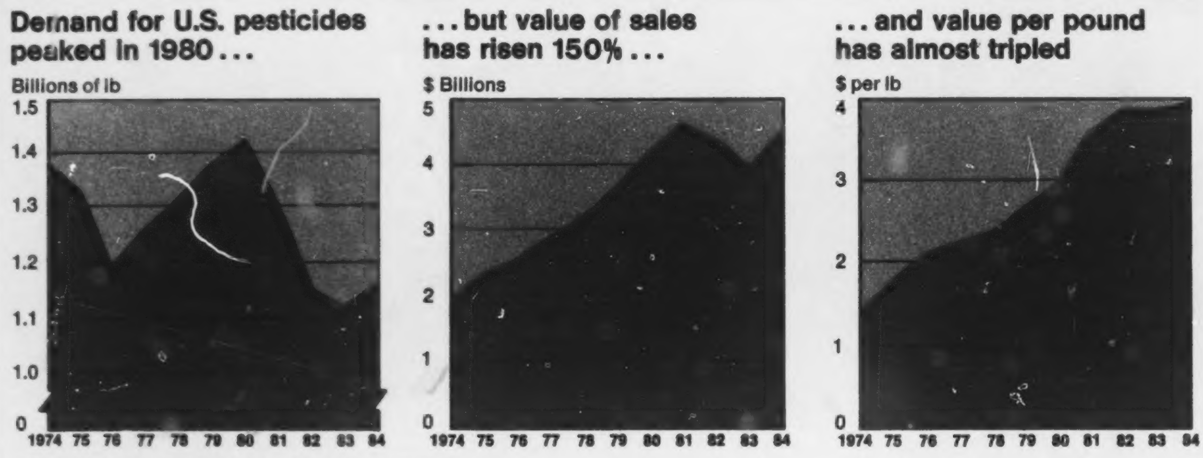
Greenhouse tests are important part of pesticide research at Monsanto's agricultural research division

Coupled with the patent problem and the high cost of entry into the marketplace are the generic producers. These are manufacturers who take products that are no longer protected by patents, and make and

Herbicides account for less than half of pesticide shipment volume, but almost 60% of value



Sources: Predicasts, C&EN estimates


Demand for U.S. pesticides peaked in 1980 . . .

. . . but value of sales has risen 150% . . .

. . . and value per pound has almost tripled

Sources: U.S. International Trade Commission, C&EN estimates

sell them at the generally lower prices that prevailed while the product was still protected. To counter the generic producers, the original manufacturer must lower its price to remain competitive. Thus, it becomes imperative that the original producer recoup its investment during the life of the patent.

Another factor affecting the pesticide market is the change in farming practices over the past few years. With these changes have come shifts in pesticide use.

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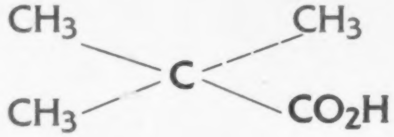

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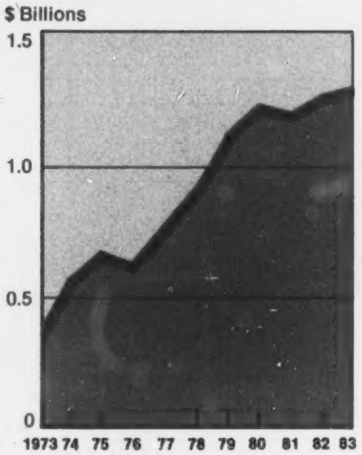
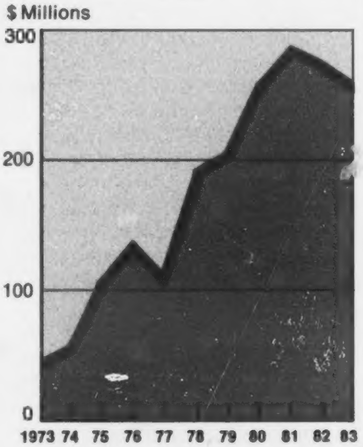
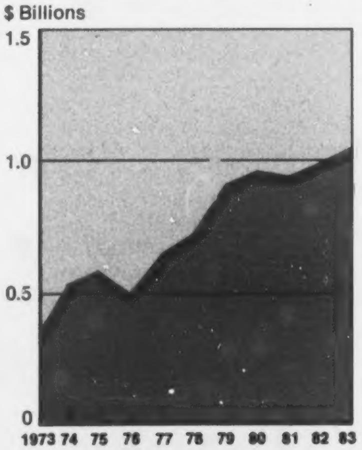


. . . while imports have fallen off . . .



. . . to give a trade surplus of more than $1 billion



Source: Department of Commerce

planting amounts to little more than breaking up the compaction of the soil in some way.

This no-till or reduced-till farming is basically a conservation practice. It leaves more plant residue or trash on the field, which reduces soil loss, increases soil moisture levels, and lowers soil temperatures. In addition, since it lowers the number of trips that a farmer must make through fields, it saves time and money in terms of wages and gasoline.

Because it is not possible to use standard cultivation techniques when no-till or even minimum-till farming is practiced, the use of herbicides increases. This is because there is a mat of debris remaining on the soil and therefore mechanical cultivators won't work. To rid the fields of weeds after the crop has emerged, herbicides must be used. There also is an increased use of herbicides prior to planting since weeds are not killed by plowing.

In a survey of 10 major producing states USDA found that about 12.7% more pounds of herbicides were used per acre in reduced-till farming than in conventional tillage farming. And in no-till practice, 16.7% more herbicides were used per acre.

Thus far corn is the main target of no-till planting. Soybeans have presented a problem because the farmer must have absolute weed control before planting. This is necessary because soybeans, being a broadleaf plant, are killed by many of the herbicides that are used. Herbicide producers say that they are, however, overcoming this problem and effective, specific postemergent herbicides for soybeans will be ready soon. Reduced-till practices are more prevalent in soybeans than are no-till.

Conservation farming is just one example of the types of innovation that farmers are practicing and that will continue to fuel pesticide growth over the next several years. Farmers must make use of every tool available to assure that their crops will flourish and pesticides are one of those tools. As one producer says, "Pesticides do nothing more than offer the farmer insurance." ☐

Announcing DuPont's four newest "Idea Intermediates."

The newest additions to the family of DuPont "Idea Intermediates," shown on the opposite page, are:

DBA Dibasic Acid
$HOOC(CH_2)_n\ COOH$
$n = 2,3,4$

Sodium Styrene Sulfonate
$CH_2=CH-C_6H_4-SO_3Na$

Triphenylboron
$B(C_6H_5)_3$

Triisopropylborate
$B[OCH(CH_3)_2]_3$

If you would like more information on any of these four products, write on your company letterhead to: DuPont Company U.S.–Room G40109, Wilmington, DE 19898; EUROPE–P.O. Box CH-1211, Geneva 25, Switzerland; JAPAN–11-39 Akasaka 1-chome, Minato-ku, Tokyo 107.

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1983 ACS Annual Report
Page 27

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CHEMICAL & ENGINEERING NEWS

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Biotechnology

Out of the lab and into
the marketplace
Page 11

Cover: Wolf Hanisch, manager of process development at Cetus Corp., uses 250-L fermenter to scale up production of enzymes

CHEMICAL & ENGINEERING
NEWS

Volume 62, Number 16
CENEAR 62 (16) 1-76
ISSN 0009-2347

APRIL 16, 1984

News of the Week

- **Long-range transfer of electrons in proteins shown by scientists at Caltech.** Page 6
- **Despite inclement weather more than 8000 attended the ACS meeting in St. Louis.** Page 7
- **ACS task force recommends 40 steps to improve education in chemistry.** Page 7
- **Photos taken at national meeting—people, equipment, St. Louis landmarks.** Page 8
- **Dow Chemical purchases stock in three companies.** Page 9
- **OSHA proposes a further reduction in the permissible level of exposure to asbestos.** Page 9
- **OTA criticizes standards for groundwater protection from hazardous wastes under RCRA.** Page 10
- **NIH initiates program on proper use of animals in research.** Page 10

International Business

Canadian chemical firms continue to show profits as economic conditions improve in the industrialized world. **Page 21**

Government

Federal government's role in transferring technological know-how to business and industry still has not been determined. **Page 23**

Annual Report

ACS highlights for 1983 include decision to launch journal in colloid chemistry, purchase of conference center. **Page 27**

Science

Genes isolated from human and from mouse T-cells are shown to code for protein similar to light-chain immunoglobulins. **Page 51**

Lower rates available for ACS Journals Online searching after 6 PM; largest metal alloy cluster known, consisting of 13 gold and 12 silver atoms, made at AT&T Bell Laboratories. **Page 52**

Priestley Medal Address

Medalist Linus C. Pauling discusses the nature of the world of tomorrow as affected by scientists and nonscientists. **Page 54**

Books

"U.S. Energy Policy: Crisis and Complacency" faults the Reagan Administration for lack of energy policy objectives. **Page 58**

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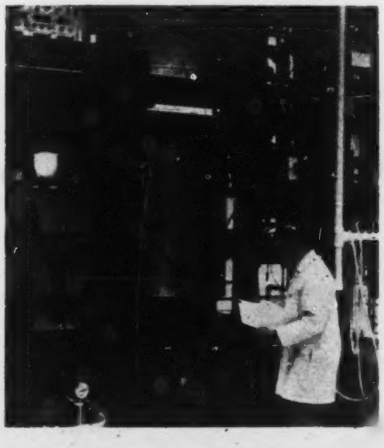


News Focus

Biotechnology firms now face their investors; decisions on research development must take into account marketability, profit potential. Page 11

drawn up licensing agreements with a number of European and Japanese pharmaceutical companies.

Other companies are attempting to implement similar strategies. The process of redefining a company along commercial rather than research lines can perhaps best be seen in the example of Cetus Corp., based in Emeryville, Calif. Cetus has redrawn its business plans extensively in the past two years. A lack of product focus in the early 1980s made Cetus the whipping boy for many analysts, who accused the company of committing the classic blunder of pursuing scientific leads without regard to realistic business potential. The lingering image created at that time clearly still rankles company executives. But Cetus believes it has rectified its earlier errors.

In 1982, the company hired a new president: Robert A. Fildes, a veteran of Bristol-Myers and president for two years of Biogen in the U.S. Fildes, who has the reputation of being a hard-headed businessman, promptly slashed half the company's projects and reset the priorities on the others. Cetus now devotes 70% of its resources to health care products (55% in therapeutics and 15% in diagnostics); 15% to agricultural products; 10% to industrial processes; and 5% to exploratory research. Before, the company had focused some 80% of its resources on the industrial area.

Cetus business plan for its health care products is to sell its monoclonal antibodies and DNA probe diagnostic tests for sexually transmitted diseases and cancer itself (either by sales force or, as is the case now with the company's cytomegalovirus test, mainly by telemarketing and direct mail advertising, or via distributors) worldwide. The company also plans to market worldwide a line of automated systems for research and clinical applications. It has the first, a laboratory liquid handling system, on the market now.

"Near term, the instruments will provide a substantial part of Cetus revenues," notes Robert E. Havranek, Cetus vice president for operations and administration. But neither those nor diagnostics will provide the kind of revenues Cetus sees in human therapeutics. "I think we can safely say that diagnostics are chosen as a short-term goal to generate revenues," Havranek says.

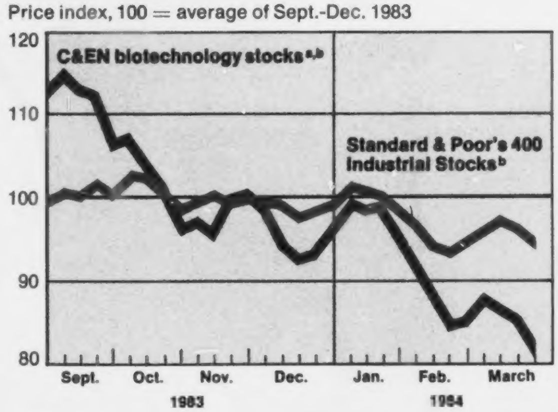
Biotechnology firms' stocks have fared poorly since last fall

For most of the new biotechnology-based companies, selling shares in their equity on the public stock market has been the largest single source of finances. In the 1982–83 bull market, more than $1 billion was invested in the new offerings of the unproved firms. So when biotechnology finance executives think about the next round of financing, they think about the price of their stock.

Since last fall, that has been gloomy work. Biotechnology stock prices, as indicated by C&EN's biotechnology stock index, were performing far better than those of the Standard & Poor's 400 Industrial Stocks last September. In the general slaughter of high-technology stocks last fall, the biotechnology issues tumbled rapidly. Since early November, they have not performed as well as the S&P 400.

The steep decline is the result of both the overall stock market's woes and investor impatience with biotechnology-based companies. "A lot depends on what the overall market does," comments Janice LeCocq of Montgomery Securities. "As long as the overall market remains cynical and antsy about anything high tech, biotech is going to feel that in spades," she adds.

Biotechnology stock prices have tumbled since last September . . .



[a] Based on stock prices for Amgen, Applied Biosystems, Biogen, Centocor, Cetus, Damon Biotech, Enzo Biochem, Genentech, Genetic Systems, Genex, Hybritech, Molecular Genetics, Monoclonal Antibodies, and Novo Industri. [b] Reindexed to average for Sept.-Dec. 1983 period to show relative change.

. . . and many stocks are now near bottom of their 52-week range

	Recent price[a]	52-week range	
		High	Low
Amgen	$ 5¾	$18	$ 5⅝
Applied Biosystems	18¼	21½	13
Biogen	12⅞	22½	9¾
Bio-Response	12	16⅛	9⅛
Bio-Technology General[b]	6	10	5
California Biotechnology	10	14	10
Centocor	9¼	20	9¼
Cetus	11⅜	19	10¼
Collaborative Research	7⅞	15½	6⅛
Damon Biotech	7¼	17½	6¾
Enzo Biochem[b]	17½	34¼	13
Genentech	37	49¾	25⅞
Genetic Systems	6	17¾	6
Genex	12⅛	23¼	12⅛
Hybritech	13½	31	12¼
Molecular Genetics	13	23	10⅞
Monoclonal Antibodies	10¾	21½	10¼
Novo Industri	46	73½	45½

[a] As of Friday, April 6, close. [b] Adjusted for split.

Canadian Chemicals See Rising Demand

Canadian chemical companies are coming off a year that saw production up, plant operating rates higher, and operating losses turned into profits.

The Canadian economy, if not booming, is still moving forward this year and pulling demand for chemicals along with it. Although forecasters differ about the absolute rate, the economy, they agree, likely will continue to grow this year.

In the U.S., the major export market for Canadian chemicals, the economy still is surging, which bodes well for Canadian chemical exporters. Elsewhere in the industrialized world, improved economic conditions are expected to help Canadian chemical exports recapture 1981 levels.

However, Canadian chemical leaders still are apprehensive about a government energy policy that threatens to prevent their industry from reaching the potential that they believe it has. A long-awaited and well-publicized report by a petrochemical task force has been submitted to Ottawa, but so far there has been no indication that government leaders are heeding the warnings and advice that it contains.

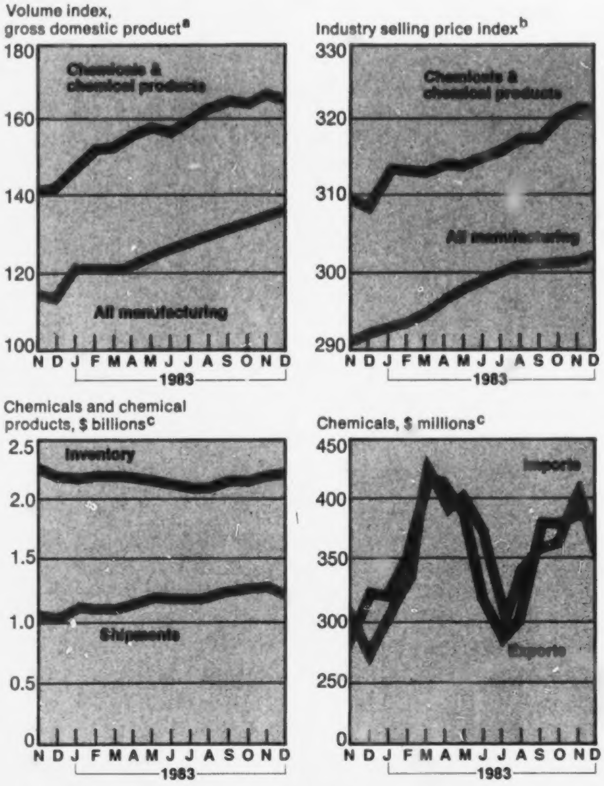
Specifically, the task force report calls for market-responsive prices for petrochemical feedstocks, which means, in effect, lower up-front taxes on raw materials. It also calls for government financial assistance to Petromont and Petrosar, the two financially troubled basic petrochemical producers in Montreal and Sarnia, respectively. These two companies, which use primarily oil-based feedstocks, have been hurt more than most by both the recent economic slowdown and government energy pricing policies. They need assistance to convert their units to other feedstocks.

Instead of an immediate indication of the government's intention to help, the chemical industry received another shock when Gulf Canada said that it was dropping its one-third stake in Petromont. The two remaining partners, Union Carbide Canada and a company owned by the Quebec provincial government, will own and operate debt-ridden Petromont jointly.

Until the troubles plaguing Petromont and Petrosar are solved, Canadian chemical leaders will continue to feel uneasy about their future because these troubles are symptomatic of troubles throughout the entire industry. Even the natural-gas-based petrochemical industry in western Canada says it needs better feedstock prices to remain competitive.

This uneasiness, however, will be tempered over the short haul at least by the fact that demand for most chemicals continues to increase. In the last half of the year, a string of new, world-scale plants (ethylene, ethylene glycol, polyethylene, and styrene) will come on stream in Alberta, swelling Canada's production totals for these major petrochemicals.

Earl Anderson, New York



a Seasonally adjusted, 1971 = 100. b 1971 = 100. c Canadian dollars.
Source: Statistics Canada

Chemical output has rebounded strongly

Production, thousands of metric tons	1983	1982	1981	% change 1982-83
ORGANICS				
Ethylene	1196	1013	1330	18.0%
Propylene	715	693	671	3.1
Benzene	580	519	572	11.7
Toluene	411	470	480	−12.7
Xylene	432	431	409	0.4
PLASTICS				
Polyethylene, low density	412	376	410	9.5
Polyethylene, high density	211	194	223	8.6
Polyvinyl chloride	248	193	222	28.4
INORGANICS				
Nitric acid	855	977	1158	−12.5
Phosphoric acid[a]	656	553	744	18.6
Sulfuric acid	3686	3131	4117	17.7
Ammonia, anhydrous	2888	2506	2654	15.1
Ammonium phosphate	1259	1027	1366	22.6
Chlorine	1385	1233	1292	12.3
Sodium hydroxide	1526	1367	1458	11.7

a 100% P_2O_5. Source: Statistics Canada

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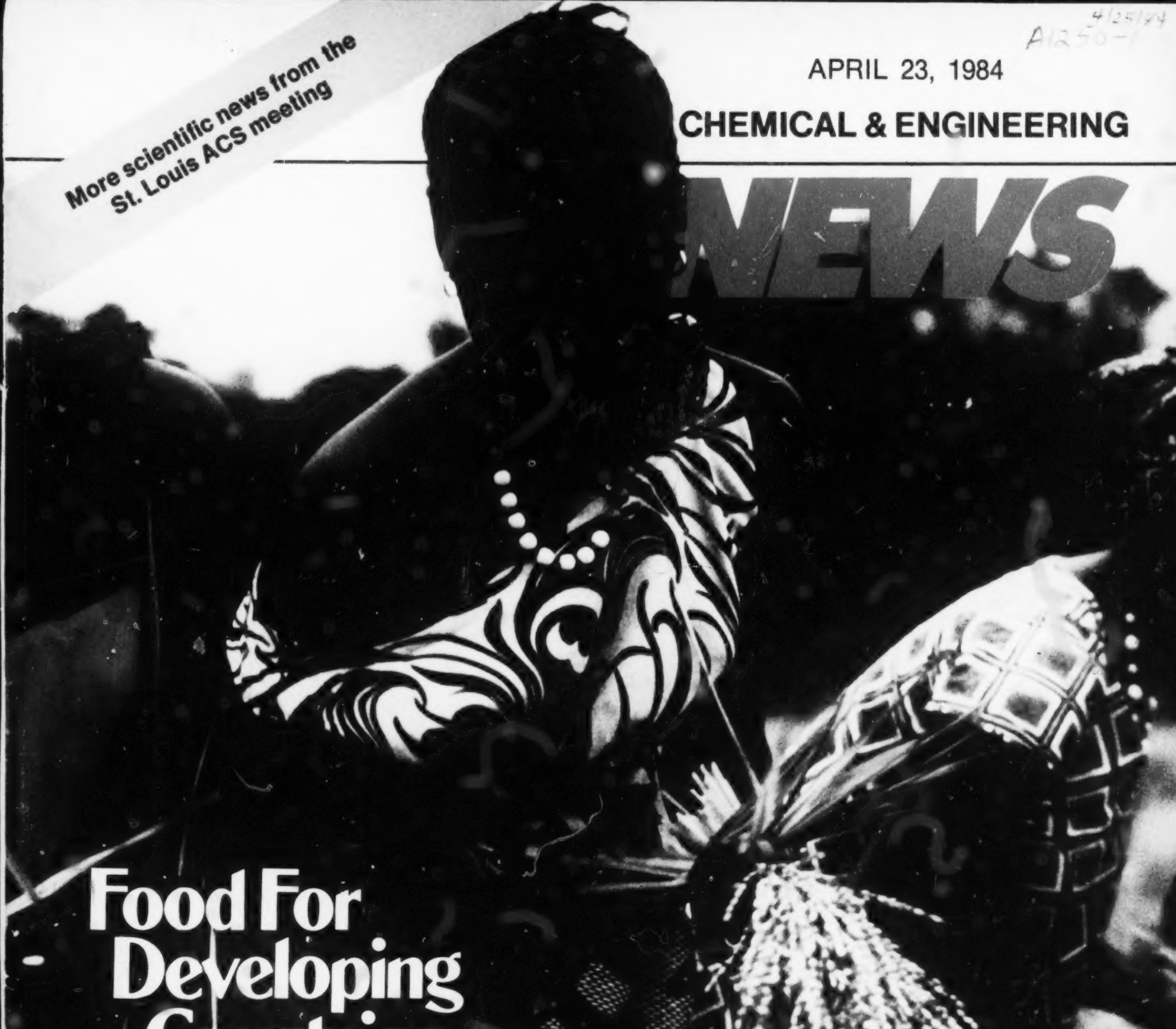
NEWS



More scientific news from the
St. Louis ACS meeting

Food For Developing Countries

Ag chemicals play
a key role
Page 32

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CHEMICAL & ENGINEERING NEWS

APRIL 23, 1984

Cover: Woman in Casamance region of Senegal harvests rice by traditional method of cutting one stock at a time. Photo courtesy of World Bank

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News of the Week

- **Variant of virus that causes cancer in humans isolated from AIDS patients.** Page 4
- **President Reagan proposes treaty to ban chemical weapons.** Page 4
- **Du Pont gives $50,000 to support buildup of the U.S. bald eagle population.** Page 5
- **Chemical industry earnings increase for the second consecutive quarter.** Page 5
- **University of Texas commits $32 million for endowed chairs in science and engineering.** Page 6
- **Texas Board of Education repeals rule requiring textbooks to consider evolution as only one theory of mankind's origin.** Page 6

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Business

Specialty chemicals are a lucrative business but players need creativity and entrepreneurship to get into the game. **Page 8**

International Business

European chemical industry is showing improvement: production is increasing, prices are firming across the board. **Page 10**

Government

House and Senate rush tax legislation through; House bill would set up bank and council for industrial competitiveness. **Page 12**

Science

From the ACS meeting: mortality study of women chemists, drugs for congestive heart failure, immunoassay method, unimolecular kinetics, protein origin, family of chemists, catalysis study, and violin making; biotechnology centers sited. **Page 16**

Education

Videodiscs developed for chemistry teaching have the potential to tailor instruction to the individual needs of students. **Page 24**

Technology

From St. Louis: Oil shale processing, weedkiller, melt catalysis systems, and call for stepped-up energy research. **Page 25**

Special Report

Food needs in developing countries must be met by bigger crop yields, increased fertilizer and irrigation use. **Page 32**

Women Chemists Mortality Study Finds High Suicide Rate

Study of women ACS members from 1925 to 1979 finds five times expected rate of suicide, risk up for some cancers, low for heart diseases

National Meeting
St. Louis

Women chemists are substantially more likely to commit suicide than are other women in the U.S. of the same age, according to epidemiologist Judy Walrath of the National Cancer Institute. In a mortality study of 347 white women members of the American Chemical Society who died between 1925 and 1979, Walrath and her colleagues found that 36, or roughly one in 10, died by suicide. This is five times the number expected from a sample of this size based on statistics for white women in the U.S. as a whole.

The study, presented at the open session of the Women Chemists Committee, is not the first one to suggest that women chemists are particularly prone to suicide, Walrath says. A 1969 study directed by Frederick P. Li at the National Cancer Institute of deaths of men and women ACS members found that 11% of the 115 women in the study died by suicide. However, the number of women chemists in this study was fairly small, so the present study was undertaken to see whether the same trend would be found in a larger sample. Li is a coauthor of the new study, as is Joseph F. Fraumeni Jr., a clinical epidemiologist at the National Cancer Institute, and Marshall W. Mead, head of membership statistics and planning for ACS.

There was an increased incidence of suicide for all three time periods examined in the study—deaths that occurred before 1960, from 1960 to 1969, and from 1970 to 1979, Walrath says. The most common method of committing suicide was by cyanide poisoning (39%), followed by barbiturates (28%), and firearms (6%). This percentage of suicides by cyanide poisoning is high; typically only 6.4% of white female suicide victims use poisons of any sort other than barbiturates. The highest suicide incidence occurred among women chemists who were divorced or widowed, just as it does among women generally. However, married women chemists were more likely than single women to commit suicide, which is not true for women as a whole.

The study does not provide firm answers as to why the suicide rate is so high for women chemists. In fact, since it uses only death certificate data to establish the cause of death and membership in ACS as the criteria for being a chemist, it does not provide a great deal of information about the circumstances surrounding each particular death. Walrath suggests that most women who engage in chemistry work in a strongly male-dominated workplace, which may increase their level of depression. That, combined with access to chemical poisons, particularly cyanide, may be a factor in increasing their suicide rate. The 1969

Rates of suicide, certain cancers high for women chemists

	Laboratory chemists		Academic chemists		Other chemists		All women chemists	
Cause of death	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
All cancers	41	36.3	**42**	**31.5**	23	18.1	**111**	**89.0**
Digestive system	9	8.1	**16**	**9.1**	5	4.5	29[a]	21.1
Respiratory system	2	3.2	2	2.4	1	1.5	5	7.4
Breast	13	8.8	9	6.8	6	4.3	**30**	**20.6**
Ovary	3	2.9	5	2.3	**5**	**1.4**	**13**	**6.7**
Lymphatic and hematopoietic systems	6	3.2	4	2.5	3	1.4	**13**	**7.4**
Suicide	**20**	**3.5**	**12**	**2.0**	**4**	**1.3**	**36**	**7.1**
Circulatory system diseases	**35**	**46.8**	**59**	**69.9**	23	28.6	**119**	**149.1**
All causes	129	129.0	141	141.0	66	66.0	347	347.0

Note: Pairs in boldface show a statistically significant difference at the 0.05 level. Data are from study of white women members of the American Chemical Society who died from 1925 to 1979, based on information from death certificates. a For stomach cancer alone, the women chemists had a statistically significant excess incidence (8 observations compared to 3.6 expected).

study shows male chemists have a slightly elevated suicide rate, and studies of other professional women, such as physicians, registered nurses, and psychologists, also show some increased risk of suicide.

There may be other explanations, however. Mead suggests that some of the women who commit suicide may have life-threatening illnesses and choose suicide as a preferable way to die. This possibility is particularly worrisome, since it could distort the value of the study to pick up other occupationally related causes of death among women chemists. Another possibility that the report's authors would like to see studied further is a relationship between chemical exposures and psychological states predisposing to suicide.

Although it is in their suicide rate that the women chemists studied show the most striking difference from other women, the study finds other differences as well. Deaths from all cancers were elevated for the women chemists (111 observed vs. 89 expected). In particular, there were significant excesses of cancers of the stomach, breast, and ovary among the women chemists, as well as in deaths from leukemia, lymphoma, and other lymphatic system cancers. On the other hand, deaths from circulatory system diseases were significantly lower for women chemists than for women generally (119 observed vs. 149 expected). Overall, the death rate from all causes for the women in the study was exactly the same as for all white U.S. women of comparable age.

The study sample, which was comprised of all female ACS members known to have died between 1925 and 1979, also included 11 nonwhite women. These women showed no unusual mortality pattern, but the sample was too small for causes of death to be examined in much detail.

Occupational histories and records of exposure to any particular chemicals were not available for the women in the study. The researchers tried to assess whether chemical exposure was a factor in differences in mortality patterns by dividing the women chemists into three broad occupational categories: laboratory chemists, academic chemists, and others. They assumed that women in the first two groups would be exposed to chemicals and that those in the third group would not be. Although the number in each group was small, the researchers did find that the increase in stomach cancers seems to concentrate among academic chemists and ovarian cancer mortality among the women who were neither laboratory nor academic chemists. Suicide rates were elevated in all three categories, but were more pronounced among laboratory and academic chemists than among the others.

Some of the high levels of cancer incidence may have nothing to do with whether the women studied are chemists, Walrath explains. Breast cancer mortality, for example, was elevated only for women who had never married and who had joined ACS since 1935. This high incidence of breast cancer among women chemists who never married or never had children is consistent with increased risk among all women in these categories. Higher education and economic status also is associated with greater risk of breast cancer. Similarly, ovarian cancer mortality tends to be elevated among women who have never married, and the ACS sample has a large number of women in this group.

In the case of stomach cancer, however, the findings of the new study seem to be in contrast with trends reported in other studies. For instance, male ACS members in the 1969 study had a significantly decreased risk of stomach cancer. This cancer also is generally associated with lower socioeconomic status and is more common among foreign-born Americans. All of the women who died of stomach cancer in this study, however, were born in the U.S.

Increased stomach cancer risk has been reported for certain chemical-related occupations, such as workers in petroleum refineries, the rubber industry, and agricultural jobs. Dietary factors also are thought to play an important role. The present study could not evaluate the effects of either of these factors. □

New drugs for treating congestive heart failure

National Meeting
St. Louis

Agents now under development or already in clinical trials show promise for treating congestive heart failure, according to a number of speakers at a symposium sponsored by the Division of Medicinal Chemistry.

Congestive heart failure is a debilitating disease unique to humans in which the heart is unable, for one or more of a number of related reasons, to deliver an adequate supply of blood to meet the metabolic needs of the body. As pointed out at the symposium, digitalis has been recognized for 200 years as a positive inotropic agent—that is, a compound that increases the strength of heart muscle contraction. However, in treating congestive heart failure, digitalis and its analogs have only a limited effect and cannot be used by many patients because of adverse side effects.

Symposium speakers described a number of new inotropic drugs that can be administered orally. All of the drugs appear to act by a mechanism different from that of digitalis.

Richard A. Schnettler and Richard C. Dage, both researchers at Merrell Dow Research Institute, Cincinnati, described the chemistry and pharmacology of imidazolones, two of which Merrell Dow now has in clinical testing. A positive inotropic effect for imidazole was first reported in 1970, Schnettler says.

According to Dage, fenoximone and a related compound designated MDL 19,205 are orally active. In studies on dogs, the compounds increase the contractile force of heart muscle. In an isolated heart and lung preparation, the researchers observed an increase in muscle contractile force and a smaller, but significant, increase in heart rate

Jury Still Out on Adapting Western Processes for Eastern Shale

Studies of processes used to process western oil shale reach conflicting conclusions, whereas some new retorting methods look good for both

National Meeting
St. Louis

Eastern oil shale is known to be different from western shale. Whether that means that the processes used for western shale are adaptable for processing eastern shale remains to be seen. However, one evaluation of five existing processes indicates that, generally, processing requirements for eastern shale are different, though processes for western shale do produce usable products, and the general retort chemistry is similar for both types of shale.

Other, independent evaluations of particular processes, on the other hand, suggest that adaptation is less difficult than first suspected. And, there are also some new retorting processes that may be not only effective for eastern shale but improvements on those now in use in the West.

The adaptability of five retorting processes now used for western shale has been evaluated by a group at Los Alamos National Laboratory. William J. Parkinson, a Los Alamos staff member, told the Division of Petroleum Chemistry that the five processes included HYTORT (Institute of Gas Technology), Paraho C-H (combination heated), Paraho D-H (direct heated), TOSCO II, and a shale-fired power plant.

The HYTORT process uses a 90 mole % hydrogen recycle and operates at a pressure of 500 psig to increase oil yield. Paraho C-H combines the shale heating and combustion in a single step. However, the process usually needs large quantities of oxygen and diluent gases to burn off residual carbon and quench combustion. TOSCO II discards a lot of residual carbon in the spent shale. Paraho D-H also discards a lot of residual carbon and requires postretort gas cleanup. The shale-fired power plant was entirely simulated.

The evaluation assumed a nominal production of 50,000 barrels per stream day and that all plants would be located near a mine where shale could be purchased at $4.00 per ton. Although there are clear indications of the relative performance from each process, there is also considerable uncertainty in some of the cost data available to the evaluators. Of particular note are discrepancies in the data on retort costs. In all cases, the cost of acid gas removal is high, and the same cleanup techniques are not appropriate to all. Parkinson says that gas cleanup costs for the Paraho D-H processes are unusually high because the process produces large amounts of low-Btu sour gas.

One of the biggest differences between eastern and western shales is the lower hydrogen-to-carbon ratio of eastern shale. This presents a greater hydrotreating effort to produce an oil acceptable to refiners. It is also the basis for much of the adaptability problems with western technology.

The general conclusions reached by Parkinson and his associates were that western shale retorting processes are not adequate for use in the East, that the HYTORT process is the best of those evaluated, and that the Paraho C-H and TOSCO II processes can be greatly improved.

A difference of opinion was registered by Michael J. Roberts, manager of oil shale operations at the Institute of Gas Technology. IGT designed the HYTORT process and recently has been doing adaptation studies for Hycrude Corp. funded by Phillips Petroleum Co. A series of small pilot studies at IGT show that oil yields can be increased up to 230% of the Fischer assay yield from New Albany shale, a type typical of the eastern shales. The yield is a direct function of the hydrogen partial pressure. The actual hydrogen pressure to be used will be an economic compromise between yield and pressure.

The indications are that, with suitable design modifications, at least one existing process is adaptable to processing eastern shale.

A new way to process shales, east-

HYTORT is best of processes evaluated on eastern shale

Process	Product cost ($ per bbl)	Total capital ($ millions)	Oil production (bbl per stream day)	Operating cost ($ millions)	By-product income ($ millions)
HYTORT (IGT)	$ 48	$2188	58,575	$428	$ 63
Paraho C-H	70	2220	34,740	391	160
TOSCO II	75	2240	36,620	390	69
Paraho D-H	106	3140	29,220	428	221
Power plant	107	577	7,277	50	None

ern and western, may be the molten salt bath. Although emphasis will probably be on producing a substitute crude oil for further refining into conventional products, the possibility exists that other products also may issue from molten salt reactors.

One type of salt bath has been under investigation by a group at Los Alamos National Laboratory and was described by Cheryl K. Rofer-DePoorter. She noted that all the processes currently under consideration involve high-temperature pyrolysis and all have similar problems—namely, they require the handling of a lot of solids, they don't recover a lot of the available carbon in the shale, and they produce only a substitute crude oil that requires considerable refinery upgrading.

Molten salt baths generally operate at lower temperatures than retorts and thereby reduce some of the problems. A lengthy search produced a candidate molten salt with the formula 1NaOH:1KOH:0.5LiOH.

Several samples of oil shale, subbituminous coal, wood sawdust, and tar sand were processed in the molten salt bath at 200 °C. Samples also were treated without the molten salts. Processing with the hydroxide doubled condensate yield from the coal and tripled the yield from sawdust. In addition, the sawdust was converted almost entirely to water-soluble products. The effects of the hydroxide on the tar sand were negligible.

Although the shales used in the molten salt experiments were all western shales, the investigators see no reason why eastern shales should not react similarly. The use of the molten salt reactor is also more generally applicable to most feeds, excepting tar sand. Why this should be so isn't known. A mechanism that is consistent with the observations has been suggested: oxidative attack on the kerogen to form carboxylic acid salts, followed by decarboxylation of the salts to hydrocarbons. Dissolution of mineral matter in the shale is a problem and appears to be temperature dependent. No sulfur or nitrogen appears in the products. □

Cutting carbonyl group stabilizes weedkiller

National Meeting
St. Louis

It's hard to invent a good herbicide, let alone bring it to market. Evidence for that hypothesis was offered to the Division of Pesticide Chemistry by chemists from FMC Corp.'s agricultural chemical group at Princeton, N.J.

The work that led to FMC's Command, a new broad-spectrum herbicide for pre-emergent weed control in soybeans, was the topic of four presentations. Command is the first commercial member of a new class of herbicides, the 3-isoxazolidinones. FMC chemists Marvin J. Konz, Jun H. Chang, Sayed A. Aly, James A. Kerschen, and John P. Kolsevich, together with research managers Kenneth Wilson and William A. Van Saun, have been involved in their development.

Describing the work that led to the discovery of the new herbicides, Konz and Chang noted that related compounds, the isoxazolidinediones, have been of interest to pharmacologists because of their analgesic, local anesthetic, and anti-inflammatory properties. Although there had been no reports of herbicidal activity, such heterocyclic ring systems are important constituents of many herbicides. So FMC undertook a synthesis program to investigate the weed-control potential of the class, particularly the 2-aryl- and 2-phenylmethylisoxazolidinediones.

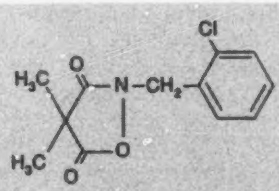
Several compounds were synthesized; one of them, 2-[2-(chlorophenyl) methyl]-4,4- dimethylisoxazolidine-3,5-dione (given the code name FMC 55626), showed great promise in greenhouse experiments. Used as a pre-emergent herbicide, FMC 55626 caused weed seedlings to emerge bleached, rather than green, and the effect was severe enough to kill the weeds. Most crop plants, including cotton, corn, and wheat, couldn't tolerate the herbicide either. Soybeans, however, were unaffected.

Later field tests brought bad news. Germinating weed seedlings were bleached, just as in the greenhouse, but they rapidly outgrew the condition and survived. Weed control was minimal, even for sensitive species. This suggested that FMC 55626 was susceptible to microbial and chemical degradation leading to loss of herbicidal activity; tests showed that that was indeed the case. In particular, the compound rapidly decomposed under mildly basic conditions, as a result of a decarboxylation reaction.

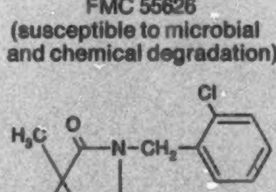
The original promise of FMC 55626 was so great, however, that Konz, Chang, Aly, Kerschen, and Kolsevich mounted a broad investigation of structure/activity relationship. The aim was to improve stability while retaining herbicidal activity. The project involved extensive structural variations of the heterocyclic ring and substituent variations on the aromatic ring. For example, experiments with isoxazolidinethiones and isoxazolin-3(2H)-ones revealed much about the electronic and structural requirements for biological activity. The studies also indicated that the compounds work by affecting carotene and chlorophyll synthesis in susceptible plants.

One of the questions that had arisen early in the study of FMC 55626 was how important were the two

Carbonyl group causes instability in compound



FMC 55626
(susceptible to microbial and chemical degradation)



FMC 57020
(stable under field conditions)

Feeding The Underdeveloped World

Chemical technology is crucial in alleviating poverty and hunger

John W. Mellor and Richard H. Adams Jr.
International Food Policy Research Institute

Social, economic, and humanitarian concerns dictate the need for a rapid increase in food production in the developing countries. Although authoritative figures are lacking, the National Academy of Sciences estimates that more than 450 million people in the world are hungry and malnourished. Most of them live in the developing countries of Asia, Africa, and Latin America, where technological and chemical inputs required for increased food production still have to make considerable headway.

Between 1961 and 1980, food production in the de-

World Bank photo

Markets, like this one in Thailand, are better stocked in many developing countries, thanks to progress in agricultural technology. But growth in population and income means that demand for food often outruns production veloping world increased at an average rate of 2.6% a year. This was slightly greater than the average annual population growth rate of 2.4%. On a per capita basis, food production in the developing countries as a whole increased only 0.2% a year. In Sub-Saharan Africa, per capita food production actually declined a shocking 1.1% a year.

Such disappointing growth rates call attention to the pressing need for technological and chemical improvements in developing countries' agriculture. Technological inputs (such as high-yield seeds and irrigation systems) and chemical inputs (including fertilizers and pesticides) play a critical role in virtually all modern methods of agriculture. In general, field studies suggest that each kilogram of fertilizer nutrients produces an average yield increase of 10 kg of grain in the developing world. And research at the International Rice Research Institute in the Philippines indicates that rice plots protected by insecticides yield almost twice as much as unprotected plots. Such yield-increasing inputs are needed to meet the burgeoning developing world's food requirements.

Population growth and rising per capita income are the two principal forces underlying the ever-increasing demand for food in the developing countries. In less-developed societies, as elsewhere, population growth fuels a steady increase in the demand for food. Such increased demand often can be met with more physical effort on a slightly larger land base. But in more dynamic societies, income growth fuels an explosive surge in the demand for food that typically exceeds the production capabilities of traditional agriculture.

Income growth accelerates food consumption because of what economists call the "high-income elasticity of demand" for foodstuffs. In the developing countries, low-income people spend the bulk of their income on food. In India, for example, the laboring class spends 60% of its income increments on grain and nearly 80% on food products as a whole. Hence, any improvement in the purchasing power of the poor has a dramatic effect on their demand for food.

Faced with growing food shortages at home, many rapidly developing countries have come to rely on greater food imports.

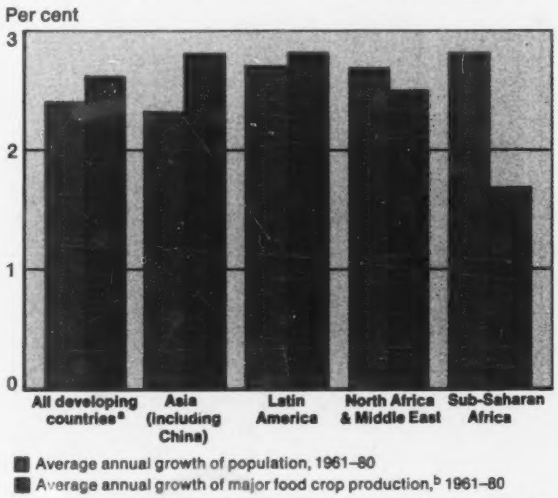
The growing dependence of many developing countries on food imports is easily demonstrated. Between the years 1966–70 and 1976–80, food imports to these nations as a whole rose at an average annual rate of 6.4%. Fueled by the high rates of income growth in the oil-exporting countries, food imports to developing countries in North Africa and the Middle East grew an unprecedented 11.3% a year. But even in the poor, drought-stricken countries of Sub-Saharan Africa, food imports increased at an average rate of 9.2% a year.

Rising food import costs in most developing countries provide an added incentive for new technological investment in agriculture. Food production presently is languishing in many developing countries because their governments are reluctant to allocate sufficient funds to the basic building blocks of agricultural development: agricultural research, agricultural extension services, rural roads, and public and private services.

For example, in Africa, a continent where per capita food production currently is declining, the average share of government spending on agriculture is only 7.6% of the total government budget. By comparison, in the Indian state of Punjab, an area where food production has grown very rapidly in recent years, the local government has allocated 11% of its budget to agriculture. This state allocation in Punjab supplements an equally high national government allocation.

In many developing countries, low government investment in agriculture reflects a relatively low priority assigned to the agricultural sector. The leadership in many developing countries has tended to equate development with industrialization, especially heavy industrialization, and generally to overlook the important role that agriculture can play in fostering industrialization. Striking exceptions to this pattern of development include Japan and Taiwan in the early part of this century and Punjab in more recent years. In these cases,

Developing countries' food production barely keeps pace with population growth



a Includes 105 Asian, African, Middle Eastern, and Latin American countries.
b Includes cereals, roots and tubers, pulses, groundnuts, bananas, and plantains.
Sources: United Nations Food & Agriculture Organization, International Food Policy Research Institute

Developing countries are becoming more dependent on food imports

	Average annual imports of major food crops[a] 1966–70 (millions of metric tons)	1976–80	% average annual growth of imports, 1966–70 to 1976–80
Developing countries	41.1	76.7	6.4%
Asia (including China)	24.0	32.5	3.1
North Africa and Middle East	7.0	20.4	11.3
Sub-Saharan Africa	2.4	5.8	9.2
Latin America	7.8	18.0	8.7

a Includes cereals, roots and tubers, pulses, groundnuts, bananas, and plantains. Rice is in terms of the milled form. **Sources:** United Nations Food & Agriculture Organization, International Food Policy Research Institute

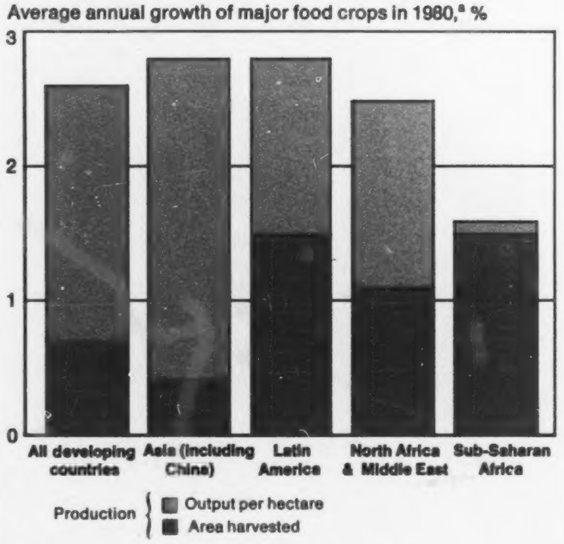
high levels of public investment in agriculture have increased food production and encouraged agricultural and industrial development.

The principal ways of boosting food production in the developing countries are by expanding the area of cropped land and by increasing crop yields.

In comparing these two approaches, Perry L. Adkisson, deputy chancellor for agriculture at Texas A&M University, says, "Increases in the area of cropped land probably will not exceed an average of 1% per year over the next 25 years and could be much less. Thus, much of the production increases need to come from increased yields. Increases in yields need to average 2.5% per year [in order to meet food demand in the developing countries]."

Rising crop yields have become the main source of growth in food production in the developing nations in recent years. Between 1961 and 1980, output per hectare of major food crops in the developing world increased an average of 1.9% annually, accounting for more than 70% of total food production growth. Increases in the harvested area averaged only 0.7% a year and contributed the other 30%.

Rising crop yields spur food production in the developing countries



a Includes cereals, roots and tubers, pulses, and groundnuts.
Sources: United Nations Food & Agriculture Organization, International Food Policy Research Institute

Increases in yields require prolonged and continuous technological change in agriculture. Depending on the particular situation, improvements in agricultural technology (such as use of high-yield seeds, fertilizers, and pesticides) produce yields two to four times higher than those achieved by traditional means. For example, the adoption of new technology in India increased average cereal yields 29% between the periods 1954–55 through 1964–65 and 1967–68 through 1977–78. Such impressive increases in yield now are needed in other developing countries.

Fertilizers play a key role in most efforts to stimulate food production in developing countries. Although the exact effects of fertilizers on total production depend on a variety of factors, many studies show their value. For example, a study by Mohinder S. Mudahar of the International Fertilizer Development Center and by Per Pinstrup-Andersen of the International Food Policy Research Institute found that increased use of fertilizer accounted for 30% of the increase in cereal grain production in the developing countries during the periods 1948–52 to 1972–73.

Such findings underscore the importance of recent trends in fertilizer use. Between 1950 and 1982, the developing countries' share of total world fertilizer consumption more than quadrupled. In 1950, total fertilizer use in the developing world stood at less than 1 million metric tons of nutrients. By 1982, this figure had risen to about 38 million metric tons.

Much of this phenomenal growth occurred during the past decade. Between 1970 and 1980, fertilizer consumption in the world's developing countries increased by more than 20 million metric tons of nutrients, compared to 13 million metric tons in the preceding two decades.

Despite such recent gains, use of fertilizer in the developing world still remains quite low. Though variations in soil fertility and cropping patterns make it difficult to compare different areas, fertilizer use per hectare in the developing world still remains only 17% of that in the industrialized countries. According to the United Nations Food & Agriculture Organization (FAO), fertilizer consumption in developing countries must rise nearly fivefold by the year 2000 to meet their growing demand for food.

Within the developing countries, fertilizer use per hectare is lowest in Africa and highest in Latin America. But even within these areas, the range of use varies considerably among countries—for example, from 4.0 to 180.0 kg per hectare in Latin America and from 3.0 to 318.0 kg per hectare in Asia. Compared to levels in some European countries, such as 740 kg per hectare in the Netherlands, fertilizer use in the developing countries has a large potential for growth.

Much of this growth will have to be supplied by im-

Consultative Group on International Agricultural Research (CGIAR) photo

Cassava tubers such as these, an important local source of starch, have been improved by breeding experiments at Nigeria's International Institute of Tropical Agriculture

ports. In 1980, the developing countries imported 38% of their total fertilizer requirements. This is only a modest decrease from 1970, when they imported 44%. Although production self-sufficiency probably will continue to rise in the developing world, many African and Asian countries will remain heavily dependent on imports from a handful of countries—Canada, the U.S., West Germany, East Germany, and the Soviet Union.

Gunvant M. Desai, a fertilizer expert at the Indian Institute of Management, notes that growth in fertilizer consumption in the developing countries "depends on a number of factors. On the supply side, mechanisms for producing, importing, and distributing fertilizer at the farm level must be developed. On the demand side, systems of research, extension [service], and credit must be established to increase farmers' demand for this input."

According to Desai, pressure from the supply side—that is, the increased availability of fertilizers—has been an important factor underlying growth in worldwide consumption. After World War II, the war-related surplus in ammonia capacity in the U.S. and other developed countries stimulated fertilizer consumption in a number of industrialized countries.

In the 1950s and 1960s, these surpluses also played a leading role in initiating fertilizer use in many developing countries. Foreign-aid programs to encourage fertilizer use grew apace. These factors help explain the more than 1500% expansion in fertilizer use in developing countries since 1960.

At present, most major developing countries produce at least some fertilizer. This reflects their desire to gain greater control over their supply of fertilizers, particularly in view of the increases in world fertilizer prices in the 1970s. Although fertilizer prices have declined in more recent years, average annual real prices between 1970 and 1980 (after allowing for inflation) rose 41% for urea fertilizers, whereas those for triple superphosphate fertilizers increased 28%.

In many developing countries, fertilizer production is curtailed by a variety of factors, including an unreliable supply of raw materials, recurring shortages of spare parts for machinery, and a scarcity of trained managerial personnel. Currently, fertilizer plants in the developing countries are being used at an average of only about 60% of capacity, even though fertilizers in many places are in short supply.

Improving the marketing and distribution facilities in rural villages could do much to stimulate the consumption of fertilizers in these countries. Experience indicates that fertilizer use never begins among all farmers and crops simultaneously. Rather, it typically starts among a small group of farmers who grow cash crops. In time, the number of farmers using fertilizers widens as local extension agents convince them of the considerable benefits of fertilizer.

Over the long term, sustained growth in fertilizer

Fertilizer subsidies far outweigh agricultural research in developing world

	Spending on fertilizer subsidies, 1969–75 ($ millions)	Spending on agricultural research, 1969–75 ($ millions)	Fertilizer subsidies as a proportion of agricultural research spending, 1969–75, %
DEVELOPED COUNTRIES			
Australia	$110.49	$113.90	97%
Austria	2.11	4.50	47
Greece	4.79	4.57	105
New Zealand	27.07	28.60	95
U.K.	75.38	60.20	125
DEVELOPING COUNTRIES			
Afghanistan	$ 15.10	$ 0.63	2397%
Bangladesh	14.63	1.40	1045
Indonesia	71.90	3.42	2102
Pakistan	20.97	1.26	1664
South Korea	27.26	2.44	1117

Source: Mohinder S. Mudahar and Per Pinstrup-Andersen, "Fertilizer Policy Issues and Implications for Developing Countries," January 1979

CGIAR photo

Greater rice production as here in Thailand depends on reliable water supplies as well as on quicker-maturing, higher-yielding varieties of seed

consumption in the developing countries requires the creation of new demand. This is primarily the responsibility of national agricultural research and extension systems. Developing countries, such as Taiwan and India, with their well-financed and well-staffed research and extension programs, can develop and disseminate the new high-yield seeds and irrigation techniques that serve to increase demand for fertilizers.

The role of agricultural research in stimulating local demand for fertilizers often is neglected. Research in Asia demonstrates that the technological advances made by national research organizations, such as the introduction of new crops and improved irrigation facilities, have been major determinants of growth in demand for fertilizers. A study by Yujiro Hayami of Tokyo Metropolitan University shows that 70% of the increase in commercial fertilizer use in Japan between 1883 and 1937 is explained by technological progress in agriculture and only 30% by lower prices.

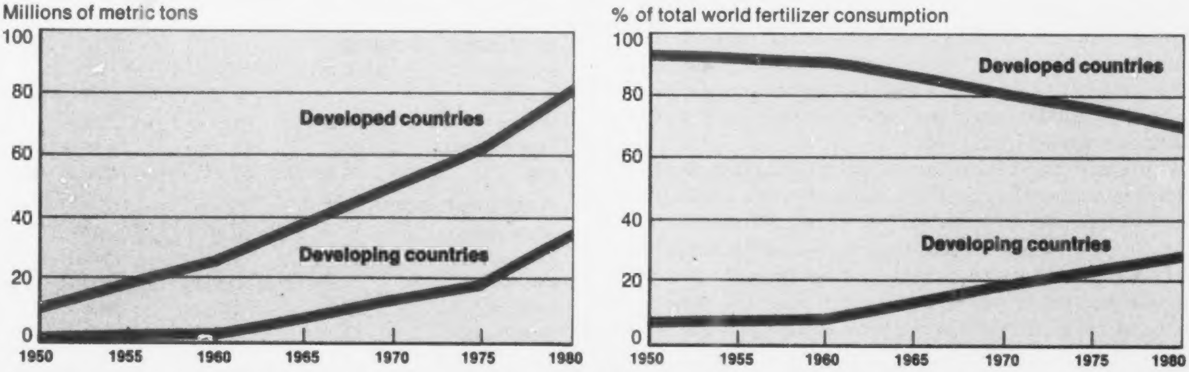
To promote fertilizer use, many developing countries' governments try to reduce prices through subsidies. According to FAO, nearly two thirds of all developing countries had fertilizer subsidy programs, at least part of the time, between 1969 and 1980. Since these programs usually begin when consumption is low, their initial costs are quite manageable. However, as use rises, so do costs. Allowed to grow unchecked, fertilizer subsidy programs can become a significant burden on government resources.

It is instructive to compare the relationship between government spending on fertilizer subsidies and agricultural research in various developed and developing countries. In Australia, Greece, and New Zealand, for example, government spending on fertilizer subsidies was about equal to that spent on agricultural research between 1969 and 1975. But in the developing countries of Afghanistan, Indonesia, and Pakistan, government spending on subsidies ranged between 1600 and 2400% of the amount spent on agricultural research.

This is a serious misallocation of government funds. Economic returns on subsidies are relatively short term, but investment in research generates a stream of economic returns for an indefinite period. According to recent studies by agricultural economists, the annual rate of return on investment in agricultural research ranges from 20 to 90%, with an overall average of 48%.

If the objective is to increase food production, it would seem that much more attention should be paid to improving agricultural research organizations and extension services in the developing countries. Effective national research organizations provide the means for developing high-yield seeds, fertilizers, and pesticides

Consumption of fertilizers grows fastest in the developing countries



Source: FAO Fertilizer Yearbooks, 1950–80 that are adapted to local conditions. In turn, the establishment of efficient, local extension services provides the means for disseminating these new technological inputs to farmers.

In recent years, many developing countries have taken steps to upgrade their agricultural research. A joint study by the International Service for National Agricultural Research and by the International Food Policy Research Institute indicates that real government spending on agricultural research in the developing countries has increased 70% since 1975. Yet much still remains to be done. More than 60% of all national expenditures on agricultural research in the developing world are concentrated in just five countries—Argentina, Brazil, India, Mexico, and Nigeria. Agricultural research still remains in a comparative state of infancy in many Asian, African, and Latin American countries.

Role of irrigation

In many developing countries, expansion of irrigated land has led to some of the largest increases in food production. D. Gale Johnson, chairman of the economics department at the University of Chicago, says, "Depending on the particular situation, irrigated land yields from two to four times as much [food] as the same land before it was irrigated. Thus, irrigating 1 hectare of land is the same as 'finding' 1 to 3 additional hectares of cropland."

In almost all developing countries, great potential exists for increasing irrigation. However, major projects require considerable lead time, as well as administrative cooperation in planning and construction. They also call for very large capital investments. A recent study by the International Food Policy Research Institute estimates that the total capital costs of producing the additional food crops needed to feed the developing countries in 1990 would be $98 billion. Almost half of these costs would go for developing new water resources.

Irrigation can increase cropping intensity (the number of crops produced per year) in areas where lack of water has limited production in the past. In many semiarid countries, for instance, effective irrigation systems could enable farmers to produce two crops a year where they now grow only one. Throughout the developing countries, increased cropping intensity is an important means of meeting the urgent need for more food.

Irrigation also can raise the income of peasant farmers. A study by Clive L. Bell of the World Bank and Peter B. R. Hazell of the International Food Policy Research Institute found that the incomes of 51,000 farm households in Malaysia nearly doubled in the seven years after a large irrigation project was completed. According to these researchers, investment in irrigation causes large increases in the incomes of land-owning farmers, who spend much of their new income on a wide range of local goods and services. In turn, the production of these goods and services expands employment and income opportunities for landless farmers and nonagricultural workers.

Many of the benefits of irrigation come about through its use together with new chemical and technological inputs in agriculture. Reliable water supplies, for example, are needed to grow high-yield seed varieties effectively. In Malaysia, irrigation facilitated double-cropping and the introduction of quicker-maturing, higher-yielding varieties of rice. And recent research in India shows that expansions in irrigation and fertilizer use are closely related. Only about one fourth of the total cultivated area in India is irrigated, but about 70% of all fertilizer is used on irrigated land. In addition, the rates of fertilizer application on India's irrigated land are about twice as high as those on unirrigated land.

World Bank photo

Agricultural research, such as this work on pollinating rice in the Philippines, is increasing in many developing countries, but remains in its infancy

Pesticides

Whereas expanded irrigation systems and fertilizer use stimulate food production in the developing countries, pesticides help to preserve the benefits of increased production. Pests such as insects, weeds, fungi, and so on cause high crop losses. For example, David Pimentel, professor of insect ecology and agricultural science at Cornell University, estimates that "total worldwide food losses from pests amount to about 45% [of total food production]. Preharvest losses from insects, plant pathogens, and weeds amount to about 30%. Additional postharvest losses from microorganisms, insects, and rodents range from about 10 to 15%."

Field experiments in the developing countries already have demonstrated the ability of pesticides to promote food production. For example, use of herbicides on experimental farms in Turkey increased wheat yields 64%.

Although research results are not always matched in

World Bank photos

Food imports, such as this grain being unloaded at Dakar, continue to rise in much of the underdeveloped world

farmers' fields, the benefits of using pesticides are not merely theoretical. These benefits of pesticide use are especially important to countries that rely heavily on agricultural exports. In Ghana, for instance, where cocoa exports provide some 60% of foreign exchange earnings, use of insecticides to control capsid bugs has helped increase cocoa yields up to 244%.

Currently, developing countries use about 20% of the world's total pesticide production, with consumption heavily concentrated in three large countries: Brazil, India, and Mexico. Average annual pesticide use in the developing countries is about 100 g per person, considerably less than in the industrialized countries. But the picture is changing; the value of developing countries' imports of pesticides grew at an average annual rate of 15% between 1974 and 1980.

Although the benefits of pesticides are undeniable, much attention in recent years has focused on their considerable social and environmental costs. Human poisonings are clearly the highest price paid for using pesticides.

In many developing countries, improper use of pesticides by untrained workers often leads to poisoning during application. Also, workers who enter treated areas too soon after treatment to weed or harvest crops are exposed to the pesticide by brushing against contaminated foliage. This has been the primary means of pesticide exposure among field workers in Central America. Although exact figures are unavailable, it has been estimated that in certain Central American countries (Guatemala, El Salvador, Honduras, and Nicaragua) a total of about 3000 to 4000 pesticide poisonings occur annually. About 10% are fatal.

By disrupting natural controls, pesticides also can have a detrimental impact on the environment. For example, many insect and mite populations remain as minor or unimportant pests in crops because natural enemies control them. When pesticides are used against one pest, its natural enemies may be reduced or eliminated. This has contributed to outbreaks of pests that previously were not a problem. For example, the use of the fungicide benomyl to control fungi in soybeans may unleash damaging outbreaks of foliage-feeding caterpillars that the fungi might otherwise have destroyed.

When outbreaks of new pests occur, additional control treatments must be used. This is particularly true in the humid tropics, where frequent and heavy rainfall creates a need for additional chemical sprayings. In these areas, the cost of such additional treatments often is so high that they become uneconomical, even though they increase crop yields.

The undesirable side effects of pesticides on the environment—in particular, their adverse effects on lower organisms needed as food by higher organisms—have led many experts to question the efficacy of an overreliance on chemical controls. Hence, there is much current interest in integrated pest management. Chemicals may well provide the basis for an integrated manage-

Use of pesticides, as on this field being sprayed in India, helps preserve agricultural production in developing nations but poses serious health and environmental hazards ment program—but chemicals used in such a way as to complement biological and agricultural controls.

In many developing countries, biological and agricultural control methods already represent the dominant form of pest control. Crop rotation, soil and water management, and the manipulation of planting dates have long been used throughout the developing countries to reduce pest outbreaks. For example, planting corn in rotation after such crops as soybeans and wheat can effectively reduce the incidence of corn rootworm.

In recent years, plant breeders have sought to extend the efficacy of such nonchemical controls by developing host plant resistance in major crops. Thus, after recent ravages of the brown planthopper in southern Asia, scientists at the International Rice Research Institute successfully developed a new variety of rice (IR-36) resistant to this insect.

A look into the future

The closing decades of this century, we believe, will see large numbers of developing countries undergoing rapid economic development. The ever-rising demand for food in these countries will place increasing pressure on them to boost their food production.

Under these circumstances, most developing countries would be well advised to place far greater emphasis on expanding agricultural production than they have in the past. Increased food output is important for continued economic growth and for the alleviation of poverty throughout the developing world. In most developing countries, accelerated growth in food production requires widespread use of technological and chemical inputs in agriculture.

The developed countries, of course, have a key role to play in helping developing nations achieve their food supply goals. Food from the developed countries is frequently essential in alleviating the shortages that occur when the domestic demand for food increases faster than local output. In addition, the developed countries have the funds and technical expertise needed by developing countries to improve their basic and applied agricultural research to expand their food production. Such assistance not only promotes steady economic growth but also relieves the serious food shortages that often accompany economic development.

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John W. Mellor (left) is director of the International Food Policy Research Institute in Washington, D.C. He was formerly chief economist for the U.S. Agency for International Development. Before that, he was professor of agricultural economics, economics, and Asian studies at Cornell University. He is the author of several books, including "The Economics of Agricultural Development" and, most recently, "The New Economics of Growth: A Strategy for India and the Developing World."

Richard H. Adams Jr. (right) is special assistant to the director at the International Food Policy Research Institute. He recently completed his Ph.D. at the University of California, Berkeley. While conducting his dissertation research, he spent two years in the Egyptian countryside, studying the dynamics of small-farm development. He is the author of several journal articles, the most recent of which appeared in the July 1983 issue of World Development.

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NEWS

Major elastomers recover steadily
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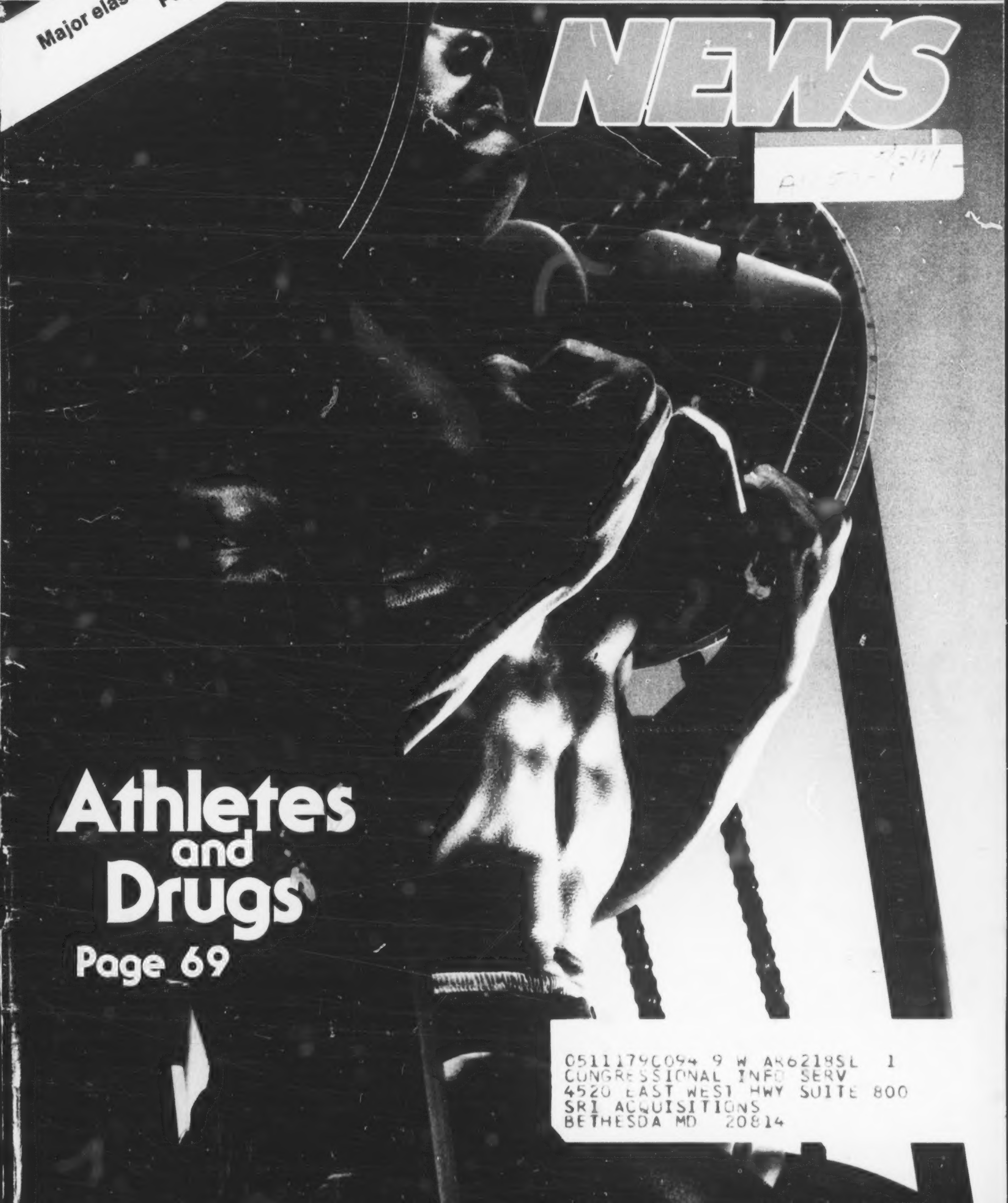

Athletes and Drugs

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CHEMICAL & ENGINEERING NEWS

APRIL 30, 1984

News of the Week

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- **U.S. chemical industry earnings in the first quarter continued the gains of fourth-quarter 1983. Page 7**
- **Badische Corp. will get into the U.S. market for engineering plastics. Page 8**
- **EPA is not expected to allow waste management firm to incinerate hazardous waste in the Gulf. Page 8**

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Government

Defense Department study claims Soviet military R&D program is high caliber and is much larger than that of the U.S. **Page 14**

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Rubber Report

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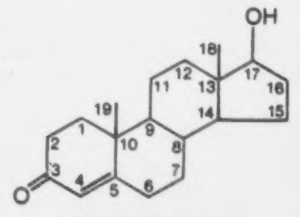


Testosterone

Special Report

Value of drugs in enhancing athletic performance is debatable as is the danger; techniques for their detection will be on hand at the Olympics. Page 69

W. R. Grace photo

Elastomers Finally Recover Growth

Bruce F. Greek, C&EN Houston

For much of the past five years, world markets for elastomers could not live up to elastomers' definition—materials that recover shape after a deforming force—but that may be changing. Although battered in both markets and raw materials by sharp hikes in oil prices, rubber is now slowly regaining its old resilience. Steady growth ahead is the view of many industry analysts.

Of course, steady growth for rubber is not on the order of growth in home video and computers. A welcome clip for the rest of the 1980s for stately elastomers would be just 3% per year, and even that rate draws considerable argument.

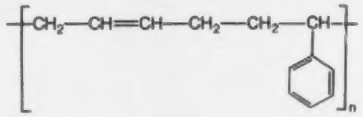
Remaining pessimism in some quarters is understandable. Some of the aftermath of elastomers' drubbing since 1979 isn't over. For example, later this year, plants at Borger, Tex., used to make polybutadiene and styrene-butadiene rubber (SBR), will be shut down. Phillips Chemical owns the SBR plant and operates the polybutadiene plant, which it owns with Armstrong Rubber and General Tire & Rubber. These plants have a nameplate capacity of 90,000 metric tons of SBR and 60,000 metric tons of polybutadiene.

But some changes are forecast for the future. Consumption of synthetic rubber will be rising from the nadir of recent times reached in 1982. During the next five years, consumption of synthetic rubber will increase at an average of 3.3% annually, according to forecasts released earlier this month by the International Institute of Synthetic Rubber Producers (IISRP).

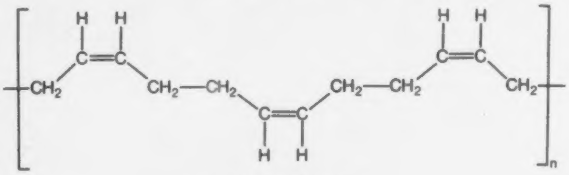
This year global consumption (excluding communist nations) of new synthetic rubber will rise to more than 5.1 million metric tons from about 5.0 million in 1983. By 1988, new synthetic rubber consumption will increase to more than 5.6 million metric tons, according

Butadiene and isoprene dominate starting materials for the major elastomers

Styrene-butadiene rubber (SBR) makes up the majority of synthetic rubber production, although its share is declining. Different polymerization technologies and modifications to the basic polymer result in many molecular forms with many different properties.

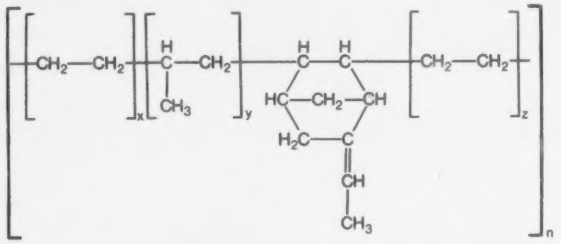


Polybutadiene rubber for most commercial uses is made with the maximum content of *cis*-1,4-polybutadiene. The volume of the transconfiguration is so small that it is considered a specialty rubber. Even much smaller in volume are the 1,2-polymers, which can be made in several forms.

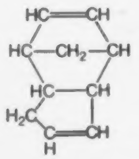


cis-1,4-Polybutadiene

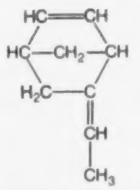
Ethylene-propylene-terpolymer rubber, sometimes called ethylene-propylene-diene monomer (EPDM), contains large numbers of ethylene and propylene groups with an occasional nonconjugated diene. Most commonly used diene is ethylidene norbornene.



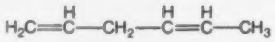
Nonconjugated dienes used in EPDM



Dicyclopentadiene



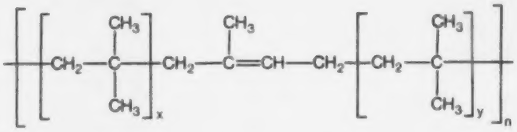
Ethylidene norbornene



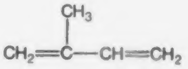
$$H_2C{=}\overset{H}{C}{-}CH_2{-}\overset{H}{C}{=}\overset{H}{C}{-}CH_3$$

1,4-Hexadiene

Butyl rubber, a copolymer of isobutylene and isoprene in its most common form, contains a large number of butyl groups relative to isoprene groups. Changing the ratio changes properties. Frequently the polymer is halogenated to give elastomers of desired properties.



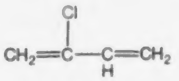
Polyisoprene rubber is similar to natural rubber in that it is high in *cis*-1,4-polyisoprene. Polymer compositions of different properties vary with catalysts and reaction conditions.



$$CH_2{=}\overset{CH_3}{\overset{|}{C}}{-}CH{=}CH_2$$

Isoprene[a] (2-methyl-1,3-butadiene)

Polychloroprene rubber (neoprene) results from 1,4 addition polymerization. The polymer contains some isomers, depending on polymerization conditions.



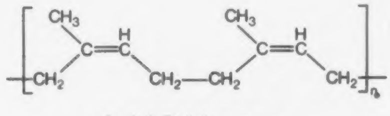
$$CH_2{=}\overset{Cl}{\overset{|}{C}}{-}\underset{H}{C}{=}CH_2$$

Chloroprene[a] (2-chloro-1,3-butadiene)

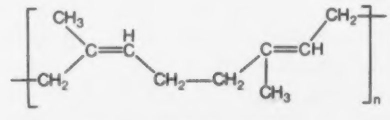
Nitrile rubber is a copolymer of acrylonitrile and butadiene with compositions ranging from as low as 15% acrylonitrile to about 45%.

$CH_2{=}CH{-}CN$ Acrylonitrile[a]
+
$CH_2{=}CH{-}CH{=}CH_2$ Butadiene[a]

Natural rubber consists of more than 98% *cis*-1,4-polyisoprene, plus a small amount of *trans*-1,4-polyisoprene, and tiny amounts of many other compounds, some of which are yet unidentified.



cis-1,4-Polyisoprene



trans-1,4-Polyisoprene

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[a] Polymer contains many arrangements of starting material.

Global synthetic rubber production has trended downward

Thousands of metric tons	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
Styrene-butadiene										
Solid	2254	2467	2583	2915	2936	2950	2750	2577	2877	3269
Latex	253	288	310	425	405	379	386	237	246	247
Polybutadiene	832	898	910	981	919	895	784	699	757	783
Polyisoprene	128	167	221	236	223	208	210	196	220	290
Ethylene-propylene	279	341	316	348	310	290	239	179	198	180
Polychloroprene	322	317	314	354	328	319	311	289	313	329
Butyl	374	406	415	441	415	386	353	316	336	349
Nitrile	182	199	207	236	208	190	181	138	195	201
Acrylates	25	31	32	32	30	29	29	28	—	—
Other	59	73	70	80	73	60	48	36	72	74
TOTAL	**4708**	**5187**	**5378**	**6048**	**5847**	**5706**	**5291**	**4695**	**5214**	**5722**

Note: Production of communist countries not included. Source: International Institute of Synthetic Rubber Producers

to IISRP's Worldwide Statistical Committee. These estimates do not include carboxylated SBR latex.

Consumption of natural rubber also is forecast to increase but at a bit slower rate. IISRP estimates that natural rubber consumption in noncommunist countries this year will rise to 3.17 million metric tons from 3.11 million in 1983. By 1988, natural rubber consumption is projected at 3.47 million metric tons.

Total new rubber consumption in the world excluding communist countries will amount to more than 8.3 million metric tons in 1984 and 9.1 million metric tons in 1988. The fraction of rubber made synthetically will hold at close to 62%.

Rubber consumption in communist countries will consist of a higher and slowly rising fraction of synthetic rubber. In 1984, total new rubber consumption will be more than 3.4 million metric tons, according to IISRP estimates. Of that total, about 78% will be synthetic elastomers. By 1988, IISRP projects that consumption will climb to 3.8 million metric tons, with synthetics accounting for almost 80% of the total.

Of the communist countries, those in Eastern Europe consume the highest relative portion of synthetic rubber, compared to total rubber use. About 86% of 2.92 million metric tons of rubber consumed there this year will be synthetic. That percentage will rise to 88% in 1988 when total new rubber consumption is projected to be 3.2 million metric tons.

As might be expected, however, for China and other Asian communist countries (grouped together for the purpose of statistical analysis), the synthetic fraction of total rubber consumption is low. In 1984, IISRP estimates that about 36% of a little more than 500,000 metric tons of total rubber consumption in these countries will be synthetic. By 1988, the synthetic fraction will rise to almost 40% of total consumption of 630,000 metric tons.

These general small increases in worldwide rubber consumption are

World synthetic rubber capacity is dropping . . .

Thousands of metric tons	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Western Europe, Middle East, Africa	3162	3139	3058	2910	2781	2696	2705	2632	2528	2520
North America	3099	3395	3437	3320	3271	3323	3426	3355	3315	3229
Latin America	511	515	517	438	396	389	378	388	297	288
Asia & Oceania	1938	1895	1866	1711	1696	1567	1512	1486	1585	1440
TOTAL	**8710**	**8944**	**8878**	**8379**	**8144**	**7975**	**8021**	**7861**	**7725**	**7477**

. . . and styrene-butadiene rubber accounts for most of the decline

Thousands of metric tons	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Styrene-butadiene	5146	5345	5448	5180	5019	4951	4991	4890	4782	4635
Polybutadiene	1339	1310	1261	1191	1176	1146	1124	1036	1099	1059
Polyisoprene	289	397	297	289	289	281	344	379	359	353
Ethylene-propylene	502	498	476	428	428	385	385	391	356	359
Butyl	583	539	533	446	498	493	466	465	429	396
Polychloroprene	431	422	433	521	416	405	405	400	389	373
Nitrile	420	428	430	428	316	314	306	300	311	302
TOTAL	**8710**	**8944**	**8878**	**8379**	**8144**	**7975**	**8021**	**7861**	**7725**	**7477**

Note: Figures include latexes, but exclude specialty rubbers; noncommunist country data only. Source: International Institute of Synthetic Rubber Producers

Glossary of rubber terms

Acrylate rubber. A class of elastomers based on acrylate esters.

Atactic polymer. A polymer type in which substituents on the polymer chain are arranged randomly. Opposite of isotactic polymer.

Block copolymer. A polymer consisting of two or more separate chain sequences, each with properties similar to those that a homopolymer would have if it were the chain alone.

Carbon black. Powdered elemental carbon used to reinforce elastomers. Differences in manufacturing give carbon blacks with varying properties in the compounded elastomer.

Coagulation. The process of converting dispersed particles of latexes into large coherent particles of elastomer. Coagulation is caused by both physical and chemical changes in the latex.

Crystallinity. Degree of orientation of polymer molecules in repeating patterns; influences properties such as stiffness and heat resistance.

Elastomer. A polymeric material that can recover its shape after removal of a deforming force. In general, this term means a synthetic polymer. By constrast, the term rubber usually means the natural product.

Emulsion polymerization. A process in which monomer particles are emulsified with a soap in water and polymerized.

Gross rubber. The total weight of salable product, including elastomer, carbon black, extender oils, and other compounding materials.

Gutta-percha. A type of natural rubber which is high in *trans*-polyisoprene; by contrast, normal Hevea-type natural rubber is high in *cis*-polyisoprene.

Hevea. The most common and largest-volume natural rubber tree genus from which the latex is taken.

Isotactic polymer. Polymer structure with repeating asymmetric atoms. Opposite of atactic.

Latex. An aqueous colloidal emulsion of any kind of rubber or plastic.

Masterbatch. The mixture of elastomer or natural rubber and other materials such as carbon black and fillers used to make the compounded rubber for final fabrication.

Natural rubber. Rubber formed in a plant, most often the tree *Hevea brasiliensis*.

New rubber. All rubber, synthetic or natural, produced or used for the first time; excludes all reclaimed or scrap rubber.

Oil content. Hydrocarbon oils added to polymer as an extender or processing aid.

Plantation rubber. Crude natural rubber from cultivated rubber trees in contrast to rubber from wild trees.

Ribbed smoked sheets. Plantation natural rubber sheets that have been passed through a ribbing mill, washed, and then hung on racks in a smokehouse.

Thermoplastic rubber. An elastomer that repeatedly can be softened by heating and hardened by cooling; not vulcanized but shows properties similar to vulanized rubber.

Vulcanization. Process for crosslinking polymer chains, causing an elastomer to become less plastic and more elastic. Often restricted to crosslinking with sulfur; by contrast, the term curing covers other crosslinking methods.

Sources: B. F. Goodrich, International Institute of Synthetic Rubber Producers

based on the assumption that no large increase in world oil prices will occur. If world oil prices should increase by large amounts for whatever reason, then new rubber consumption likely will decline again, as it did following the large increases in oil prices in 1974 and in 1979.

The impact oil price increases have had on rubber consumption has been severe. Excluding local production in communist countries, global synthetic rubber production dropped 4% in 1974 from the previous peak in 1973 and nearly 23% in 1975 from the 1973 peak.

Recovery in synthetic rubber production began in 1976 and continued through 1979 when total production in noncommunist countries reached more than 6 million metric tons. Then another slide began when production dropped 11% in 1980. The slide continued through 1982 with production in that year down more than 22% from 1979.

For the previous 18 years (1956 to 1973), synthetic rubber production had grown at an annual rate of 9.7%. This growth had resulted from three major factors. The Korean conflict had caused the price of natural rubber to more than double in less than six months, making it clear that natural rubber could very quickly become an unstable commodity. In 1949, the development of "cold" (4 to 5 °C) polymerization technology led to rubbers with much higher strength and recovery properties. In 1950, oil extension of synthetic rubber was developed, which greatly improved costs of using it.

Then in 1955, the U.S. government sold some 25 plants built during World War II to make monomers and synthetic rubber. The law covering the disposal also removed all restraints from independent research and development and permitted exportation of synthetic elastomers and technology, which had been severely limited under government ownership.

These actions radically changed the world rubber business. Good quality synthetic elastomers became available on a worldwide basis. Rubber demand, restricted because of limited availability of natural rubber, boomed. In the years 1956–73, worldwide demand for all types of rubber tripled.

Rapid expansions of capacity to make synthetic elastomers took place in many parts of the world. Rubber demand outside the U.S. increased even faster than U.S. demand. The U.S. share of the world market for rubber dropped from 42% in 1956 to about 27% in 1974.

Then came the oil price increases. The results are well known—inflation, smaller cars with smaller tires, less driving, and a big decline in U.S. car production. Coincidentally, but partly as a result of the oil price increases, much wider acceptance of radial tires occurred. All these

Both total rubber consumption and fraction supplied by synthetics will rebound over next five years

Thousands of metric tons	1982	1983	1984	1988
Noncommunist countries				
Synthetic	4,815	4,994	5,139	5,630
Natural	2,980	3,110	3,169	3,469
Total	7,795	8,104	8,308	9,099
% Synthetic	61.8%	61.6%	61.9%	61.9%
Communist countries				
Synthetic	2,556	2,600	2,684	3,048
Natural	726	741	752	778
Total	3,282	3,341	3,436	3,826
% Synthetic	77.9%	77.8%	78.1%	79.7%
Total world				
Synthetic	7,371	7,594	7,823	8,678
Natural	3,706	3,851	3,921	4,247
Total	11,077	11,445	11,744	12,925
% Synthetic	66.5%	66.4%	66.6%	67.1%

Source: International Institute of Synthetic Rubber Producers

factors combined to reduce rubber demand further, especially after the second big oil price increase of 1979.

The correlation of rubber consumption and motor fuel consumption also developed clearly as the 1980s began. U.S. rubber consumption in tires fell beginning in 1974; it recovered to a new high in 1977 and fell again through 1982. By 1982, rubber consumption in tires had declined to slightly less than 1.4 million metric tons, down 33% from the nearly 2.1 million metric tons consumed in tires and tire products in 1977.

Rubber consumption in tires was about 1.4 million metric tons in 1983

In the major Western European countries, rubber consumption in tires fell more slowly and to a smaller degree, dropping 16% from about 1 million metric tons in 1977.

In Japan the situation was different, with consumption rising through 1980 after small declines in 1974 and 1975. By 1982, however, demand was off almost 10%.

The drop in U.S. consumption of rubber in tires and tire products between 1973 and 1983 shows why the rubber business became so difficult. Rubber consumption in tires in 1983 was down 628,000 metric tons from 2.022 million metric tons in 1973. Of the total decline, 546,000 metric tons were synthetic elastomers. (Natural rubber use declined fractionally less because of the shift to radial tires, which use more natural rubber.) Passenger tire production dropped from 202 million in 1973 to 168 million last year. Also, during the same time, the average weight of a passenger car tire declined, from 13 kg in 1973 to 9.8 kg in 1983. Commercial tire production also fell 8% over this period, whereas average weight rose 1%. The loss in rubber consumption in tires because of downsizing of tires, IISRP estimates, amounts to 266,000 metric tons. The loss as a result of fewer tires amounts to another 222,000 metric tons. Commercial and other tires and miscellaneous uses account for the remaining 140,000 metric tons of decline.

Now, however, the worst may be over for the consumption loss in tires. Both the downsizing of tires used on U.S. cars and the switch to radial tires appear to be about complete. The tire sizes used on European and Japanese cars also are expected to be relatively stable.

Therefore, according to industry analysts, the amount of rubber used in tires will relate most closely to the number of tires being produced. The number of tires being produced, in turn, will relate to car production. It also will relate, but less precisely, to average age of cars on the road. A rising age of the car population would tend to mean more sales of replacement tires. But the correlation isn't direct because of the rise in use of radial tires, which offer 50 to 100% longer tread life than previous tire types. In addition to longer tread life, tire makers have improved other properties that lengthen the lives of tires, such as better resistance to ozone.

Other factors are affecting tire life and, in turn, the eventual amount of rubber used in making tires. Front-wheel-drive cars as well as lighter cars also are improving average tire tread life.

The emphasis on fuel economy also has a growing impact on tire life. Fuel economy can be improved by reducing the rolling resistance of tires. One way to achieve a quick gain in this area is to raise tire inflation pressures. Generally, an increased inflation pressure within reason also will improve tire life significantly.

Tire makers continue to face the problem of making the correct tradeoffs between such factors as ride quality, handling, reduced rolling resistance, and cost desired by auto makers and tire life, trouble-free use, and cost wanted by the car-buying public. Besides improvements in

A history of rubber

Synthetic elastomers started as did most other synthetic products because of chemists' interest in natural products. The resulting high-molecular-weight elastomers are distinctly different from natural rubber, although with some closely duplicated properties.

Purists still like to distinguish between natural and synthetic rubber, reserving the word "rubber" only for the natural product tapped from trees and using "synthetic elastomers" for polymers made in chemical plants.

Europeans began to experiment with natural rubber in the early 16th century after Spaniards brought it back from the American Indians. By the 19th century, natural rubber's properties were known widely, and a limited amount of rubber fabrication was being done. Then development followed rapidly with these important milestones:

1839. Charles Goodyear in the U.S. discovered vulcanization.

1876. Henry Wickham smuggled 70,000 seeds of a rubber tree, *Hevea brasiliensis*, to London where enough germinated to enable later plantations of cultivated rubber trees in Ceylon.

1888. John Boyd Dunlop in Belfast patented a pneumatic tire.

1900. Automobile production became significant and tire demand rose fast.

1909. Fritz Hofmann in Germany received first synthetic rubber patent.

1910. Natural rubber prices rose to $3.20 per lb spurring interest in developing synthetic elastomers.

1916. Methyl rubber made from dimethylbutadiene reached production rate of 150 tons a month in Germany.

1929. Synthetic elastomers similar to modern styrene-butadiene and nitrile rubbers were developed in Germany.

1932. Natural rubber prices fell to all-time low of 3.5 cents per lb.

1939. German synthetic elastomer capacity reached 150,000 tons per year; Soviet production reached 90,000 tons per year.

1945. U.S. synthetic rubber production exceeded 700,000 tons.

1950. Rubber demand rose to level where natural rubber clearly could not supply all needs; synthetic elastomer capacity was expanded in many parts of the world.

1979. Synthetic elastomer production in noncommunist countries reached peak of 6.167 million metric tons.

physical design of tires, tire makers are making chemical improvements in their synthetic elastomers to help achieve desirable properties in tires.

All of these improvements unfortunately offer scant hope to rubber producers. Opinion varies widely on the longer-term outlook for U.S. consumption of elastomers in tires. One view is that, on average, for the rest of the 1980s the number of tires produced will increase at a 2% annual rate at best. But because of the improvements in tires and their use, changes in tire size and car weights, and production of more radial commercial tires, the gain in use of elastomers in tires will be tiny if any. In fact, there's a chance that use of elastomers in U.S.-made tires will decline slightly over the next few years.

Part of the problem of lower U.S. tire and elastomer output comes from the rising share of imported cars sold in the U.S. in recent years. Capacity to make rubber and tires has been reduced to about the demand level, with further reductions in demand leading to the plant shutdowns exemplified by those planned for this year by Phillips and its partners.

A more optimistic view holds that synthetic rubber demand will grow at about the same rate as gross national product, possibly higher because of the more rapid growth of those rubbers, such as ethylene-propylene-diene monomer (EPDM), that go predominately into nontire uses. Tire uses in developing countries could pull along SBR, too, as demand for automobiles and other vehicles in those countries expands more rapidly than in developed countries during the next two decades or so.

IISRP forecasts widely varying growth rates for synthetic rubber consumption in various regions. For example, the annual average growth rate forecast for North America for the next five years is about 2.4%. For Western Europe, Africa, and the Middle East, the rate is about 1.7%. For Asia and Oceania, the rate is about 3.3%. But for Latin America, including Mexico, the rate jumps to 7%, even though the base is small.

U.S. synthetic rubber production is up from recession but not nearly to previous highs

Thousands of metric tons	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Styrene-butadiene	905	879	1032	1074	1378	1395	1395	1333	1179	1466
Polybutadiene	333	268	342	311	397	378	361	353	290	310
Ethylene-propylene	175	123	178	145	176	174	158	130	84	126
Polychloroprene	115	119	143	151	183	161	165	165	144	163
Nitrile	55	45	66	63	75	73	70	73	55	88
Other[a]	396	301	373	327	319	379	334	305	229	406
TOTAL	1979	1835	2134	2071	2528	2560	2483	2359	1981	2559

[a] Includes such elastomers as polyisoprene, butyl, silicone, and urethane rubbers. Sources: Department of Commerce, industry sources

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Synthetic elastomer production in the industrialized areas of Western Europe, of the Middle East and Africa; of North America; and of the noncommunist areas of Asia and Oceania all ran well below profitable levels in 1982. Only Latin America, including Mexico, had a good operating rate, but the capacity total there is small.

Capacity utilization ranged from 54% in Europe to 83% in Latin America. It's likely that more plants will be shut down and that capacity in the noncommunist areas is sufficient to meet demand for synthetic elastomers through this decade.

Worldwide capacity to make synthetic elastomers, excluding communist countries, continued to rise until the recent recession made its impact on rubber demand clearly felt. As might be expected from the decline in rubber used in making tires, the workhorse polymer SBR took the brunt of the decline. Of the decline in consumption in the U.S. of the amount of rubber going into tires of some 600,000 metric tons from 1973 to 1982, more than 85% was in synthetic rubber. Of that, 75%, or more than 400,000 metric tons, was SBR.

In 1983, total estimated SBR consumption (both solid and latex but excluding carboxylated latex) in noncommunist countries rose a bit more than 100,000 metric tons to about 2.65 million metric tons. In 1984, consumption likely will be up another 100,000 metric tons, according to IISRP.

In the U.S., as in other industrialized areas, consumption of SBR has been trending toward maturity. Analysis of consumption growth of all synthetic rubber by Shell International Chemical indicates that SBR growth will be close to that of general industrial activity. Since EPDM and others, especially the specialty rubbers, are forecast to have higher growth rates than that of industrial activity, growth of rubbers such as SBR and polybutadiene could be below that of gross national product in industrialized areas.

The nontire uses of SBR could grow at a higher rate than tire use, but competition from other elastomers hinders even this growth.

Tires take 65% of rubber in North America

Rubber type	Percentage use in tires
Styrene-butadiene	74.1%
Latex	4.1
Polybutadiene	85.0
Polyisoprene	64.9
Ethylene-propylene	10.6
Polychloroprene	1.1
Butyl	80.0
Nitrile	0.8
Other	6.1
TOTAL SYNTHETIC	60.5%
Natural rubber	75.7
TOTAL RUBBER	64.8%

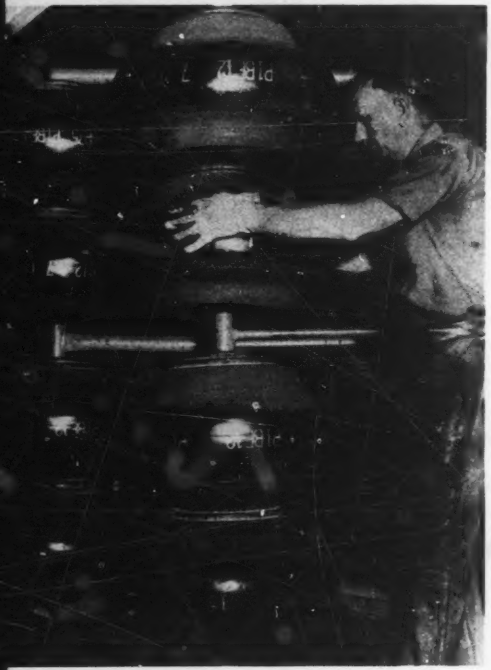
Source: International Institute of Synthetic Rubber Producers

Much SBR is blended with other elastomers to get better properties in the fabricated product. Cost of SBR keeps it in a favored position even as other materials impart somewhat better properties. By holding down price of the rubber, producers cover their cash costs of making it, but get nothing to put into development of better polymers.

The nontire uses of SBR are not expected to increase very fast because of the competition. With a significant fraction, about 10%, also going into automotive uses, automobile production influences these uses as well. This year with improved auto production, the nontire uses also could be up strongly. However, long term, the outlook is for growth of about 3%, better than that for tire use, but still not enough to help SBR much.

And it's still possible that more SBR plants may be shut down. Currently, American Synthetic Rubber's plant is not operating, but it has not been scrapped. By the end of this year, the only plants operating will be either directly owned by tire makers or closely related to a tire maker. Most of them likely will continue operating, although parts or trains could be shut down during periods of recession if rubber demand should decline. Considerable flexibility exists in the larger plants to reduce operations and save costs in this way.

The state of affairs for polybutadiene is similar in many ways to that



Radials, shown here in early stage of production, dominate the tire market

for SBR. Both, for example, have a predominate use in tires. More of polybutadiene's total use goes for tires, in fact, than with SBR; some 85% of North America's use of polybutadiene last year went to tires and tire products. Both elastomers are affected by the plant shutdowns at Borger. And both are likely to have relatively low growth in the near term because of the changes in tire life and size.

Global polybutadiene capacity, excluding communist countries, has continued to rise slowly since 1975 and reached about 1.3 million metric tons per year in 1982. Further capacity increases are in doubt for some time because of the current overcapacity and prospects for very slow growth in consumption. A decline in capacity temporarily may result because of the shutdown of the Borger plant. Small expansions have been disclosed in the past two years, but the recession may have slowed them.

To some extent polybutadiene hurt SBR consumption following its commercial introduction in the U.S. in 1961. Polybutadiene can provide better tread wear and rolling resistance properties in tires than SBR. It also has somewhat better properties of flexibility and resistance to heat buildup and aging.

Following the introduction of polybutadiene, consumption built up rapidly. By the fourth year of production, consumption of this rubber had reached 100,000 metric tons and by the eighth year, 200,000 metric tons. Use topped 400,000 metric tons in 1977 and has fallen some since then, with intermittent increases depending on economic conditions. In 1983, U.S. production rose more than 15% from 1982 to 333,000 metric tons.

The outlook for polybutadiene is about the same as that of SBR—good growth in years of economic recovery and declines in production during recessions. The average growth forecast over the long term, because of tire production and tire life, could be the same as for GNP or possibly even less.

Butyl rubber and polyisoprene rubber are other major volume synthetic elastomers going into tires and tire products. Currently there is only one producer of each in the U.S. Exxon Chemical makes butyl rubber at Baytown, Tex., and Baton Rouge. Goodyear Tire & Rubber makes polyisoprene at Beaumont, Tex. Production data for these two elastomers are not available other than in the "other" category for U.S. elastomer production.

Worldwide (excluding communist countries) consumption figures for butyl and polyisoprene rubber have been reported in the past by IISRP. These data for years up to 1982 show the typical peak in consumption in 1979 and a subsequent decline because of the world recession. However, more recent data are not available. Again, because their major use is in tires, the growth outlook for these two elastomers is similar to or less than that for GNP.

Nontire uses of these elastomers are varied. For butyl rubber, the majority of these applications are for the rubber without halogenation, whereas more than half of butyl

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Synthetic rubber consumption per capita has slacked off

Kilograms per capita	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
U.S.	7.8	9.1	8.3	11.0	11.3	11.3	10.0	9.2	13.9	11.6
Canada	7.4	8.6	8.1	9.6	8.6	8.8	8.8	7.9	8.1	8.5
U.K.	3.2	3.9	4.5	5.3	5.5	5.7	5.8	4.7	5.0	5.9
West Germany	6.4	6.4	7.1	7.2	6.9	7.0	7.1	5.8	6.6	7.2
France	5.0	5.6	5.3	5.8	5.5	5.5	5.4	5.2	5.9	5.9
Mexico	1.7	1.7	1.6	1.5	1.4	1.4	1.4	1.2	1.4	1.0
Brazil	1.5	1.6	1.9	1.8	1.9	1.8	1.8	1.6	1.6	1.5
Japan	6.7	7.2	7.6	7.1	6.4	6.1	5.8	5.2	5.6	6.6
Taiwan	3.8	4.1	5.5	5.1	4.1	3.6	2.8	1.7	1.8	2.4
South Korea	2.8	3.5	3.7	3.3	3.1	2.3	1.7	1.7	1.3	1.1
China	0.15	0.11	0.12	0.10	0.09	0.08	0.06	0.06	0.06	0.06
Eastern Europe	5.9	6.0	6.7	6.7	6.5	6.1	5.7	5.6	5.0	4.5
WORLD AVERAGE	1.8	1.9	1.9	2.1	2.0	2.0	1.9	1.8	1.8	1.9

Source: International Institute of Synthetic Rubber Producers

used in tires is either chlorinated or brominated to improve its compatibility with other synthetic elastomers. The nontire miscellaneous uses of polyisoprene are most often as a replacement for natural rubber; other uses of significance are in mechanical goods such as automotive and medical applications and in footwear.

Nontire uses could be the key to success for EPDM, often cited as the fastest growing of the major-volume synthetic elastomers. A 21% worldwide growth is forecast by IISRP, excluding communist countries, between 1983 and 1988, representing a rise from 343,000 metric tons to 416,000 metric tons. This consumption will be well up from the recent historical low set in 1982 at about 279,000 metric tons.

About 10% of U.S. consumption of EPDM now goes into tires, especially as the elastomer in the white sidewall stripe material. Other automotive uses include hoses, weather seals, grommets, and the like, which take another 15% of the elastomer. These and smaller automotive uses of polymers and elastomers modified with EPDM bring the total of all automotive uses of EPDM to about a third of its total consumption, perhaps a bit less.

One of the faster growing applications of ethylene-propylene elastomers, both the copolymer and the terpolymer with a nonconjugated diene, is in modifying thermoplastics, particularly polypropylene. Many variations of polymer modification and of manufacture of thermoplastic olefin elastomers are done to meet end product requirements. This seems to be a fertile field for new product development with large and small companies working in it. Growth rates for the near term in these areas could hold in the 10% annual rate, although the base is small.

The most talked about growing use of EPDM is in single-ply roofing. This use could reach 30,000 to 35,000 metric tons of EPDM in 1985, up from a third of this amount in 1981. EPDM's resistance to ozone and to general weathering makes it the dominant elastomer in this use. Other advantages helping its rapid growth of 20% or more annually in this use are its relatively lighter weight if compared to builtup roofs, ability to be used over heat-sensitive insulation materials such as polystyrene or polyurethane, and lower installation costs.

Because of the current diverse uses and expected future uses, more development money goes into EPDM technology than into other major-volume elastomers. This investment could lead to more investment in capacity if estimates of growth hold up.

Of all the synthetic rubbers, polychloroprene (neoprene) seems to be in the most trouble. In the U.S., production in 1983 fell slightly from 1982, down 3.2% to 115,000 metric tons, making it the only major-volume rubber to have smaller production in 1983 than in 1982. Exports, which account for 30 to 40% of U.S. production, fell more than 10% last year, causing the decline. U.S. consumption rose nearly 20% in 1983.

Although use of polychloroprene in tires is negligible, about a third

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of U.S. consumption goes to automotive uses by being fabricated into belts, wire covering, and the like. Nonautomotive wire and cable uses take a quarter of consumption as does manufacture of adhesives.

No major use development seems to be coming for polychloroprene, so consumption forecasts are for small growth of 1 to 2% annually. Prices for the elastomer are relatively high. Therefore the cost of using polychloroprene must be weighed against its very desirable properties of resistance to ozone and weathering, high strength, and high resilience. Cost and competition from other materials for use in severe service make the outlook for polychloroprene that of slow growth for the longer term.

Nitrile elastomers, another of the older synthetic rubbers, also face slow going. Growth worldwide, excluding communist countries, will be modest, perhaps 3% annually over the next five years. Production in the U.S. in 1983 totaled 55,000 metric tons, well down from the previous high set in 1974 of 88,000 metric tons.

Prices for nitrile elastomers run around $1.00 per lb, making it prohibitively expensive unless its properties can't be supplied by another product. Its high resistance to oils makes it desirable in automotive uses such as hoses and gaskets.

A large number of specialty elastomers are made in varying quantities, with a total of somewhat more than 100,000 metric tons a year. Production and consumption data for these materials are meager, especially since butyl and polyisoprene statistics now are grouped into the "all other" category. The more important specialty elastomers in terms of estimated production volumes are the urethanes, silicones, chlorosulfonated polyethylenes, and polysulfides.

Although new developments in production and use of the specialty and other low-volume synthetic rubbers will get the most attention, the workhorse of the rubber business will continue to be SBR. More than half of the worldwide consumption of synthetic rubber will be SBR and about a third of all rubber consumption will be SBR. As the major tire rubber, SBR, too, will lead the resumption of growth in the synthetic rubber industry.

The pace of growth will be nothing like it was during the 1960s and the early 1970s, but it could become steadier than that of the past 10 years. For most rubbers, sufficient capacity exists to meet expected growth, thereby reducing investment capital needs for the rest of this decade. Supplies of monomers will be adequate unless another major stoppage of world oil supply occurs. These factors then could make the rest of the 1980s a time of better profit for well-managed companies in the synthetic rubber industry. □

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C&EN's Top 50

Chemical Products & Producers

Last year looked bad for U.S. chemical producers. It was characterized by flat prices, layoffs and voluntary retirement programs instituted to avoid outright layoffs, and many plant closings. It also was a year of the leveraged buyout, with many companies getting out of businesses that they deemed unprofitable and selling them to investment groups who thought that they could make them profitable.

However, on final examination, things were not so bad as at first perceived. Granted, pricing was and still remains a problem. Chemical price inflation in the past year generally has been lower than overall U.S. inflation. But increased demand somehow was able to compensate for this, driving chemical sales up from the year before. The actions on employment, plants, and product lines provided increased productivity, which gave the industry enough earnings leverage to nearly double chemical earnings for the top companies from the previous year.

The results of an improving economy are evident in C&EN's annual survey of Top 50 chemicals and Top 50 chemical producers. Production of the Top 50 basic chemicals increased 7.7% in 1983 over 1982. This in no way makes up for the huge drop between 1981 and 1982, but it shows that recovery is moving ahead. Most chemicals contributed to the increase, with organics leading with a 15% increase. Inorganics, hurt by government agriculture policies, still managed a 4.5% gain over the year before.

The improvement also was evident in producers' financial results, with chemical sales increasing about 6% over the year before and operating profit up more than 80% from 1982. In the case of operating profit, this still does not bring the companies back to 1981 levels, but, again, it reflects the general improvement.

Producers now are looking forward to a much better 1984 and, barring unforeseen catastrophe, it looks as if they are going to achieve it. Early results indicate the first quarter of this year went well for the industry. If the improvement continues, the chemical industry may be able to regain all that it has lost in the past few years.

Basic chemical output returns to growth

Top 50 Chemical Products

David Webber, C&EN New York

The U.S. chemical industry ended a three-year production losing streak in 1983. Output of C&EN's Top 50 chemicals, which include both organics and inorganics, increased some 7.7% over 1982. It was an improvement that was welcome to chemical makers, but after 1982's 16% crash it left plenty of ground to be regained.

The overall increase also masks the unevenness of the recovery. Of the 50 products, output rose in 36 cases and fell in 14. Organic chemicals, which had slipped the worst in 1982, rebounded at a 15% rate. Inorganic chemicals, on the other hand, registered only a 4.5% increase in production. In 1982, by contrast, output of virtually every one of the Top 50 products declined. In addition, the rate of decline was fairly evenly distributed in that recession year: Organics production fell 18%; inorganics production, 16%.

The relative tepidity of the production recovery—compare it with a 9.2% increase in 1976 after the big 1975 recession—means that industry's long-term performance, already looking very lackluster last year, remains just as dull. Over the past five years, annual output actually has fallen a total of 1%. That compound rate, for the 1978–83 period, matches the decline for 1977–82, the first five-year period ever in which the chemical industry recorded such a reverse. Nor has even longer-term performance been more encouraging. Since 1973, production has been essentially flat. Organic chemicals have managed a meager 1.5% compound annual growth rate, whereas inorganics, which account for over twice the poundage of the organic segment of the Top 50 list, have grown at an overall rate of just 0.7% during the decade.

The 7.7% production increase also fails to match the rise of the Federal Reserve Board's industrial production index for all basic chemicals—a wider product

About the Top 50 list of chemical products

Government data, trade association figures, and industry estimates all go into preparing C&EN's annual list of the Top 50 chemical products, ranked by production volume. The federal government is relied upon most heavily, but when government figures are not available, other sources, primarily trade associations, are used. Industry sources and C&EN estimates are used only when other data are lacking.

Government data are not always accurate—they are only as good as the information that individual companies report. But they are an objective measure of production extending back for many years. Therefore, relatively accurate indications of growth can be made on a consistent basis.

At this time of year, C&EN has access only to preliminary reports of production for 1983. When the government and trade associations issue their final reports, the outcome can be changed, sometimes dramatically. As a result, production figures for 1981 that appear in the table on page 9 are different in some cases from those published in last year's Top 50 report. The final reports also can affect the rankings of chemicals. The 1982 rankings of 32 of the chemicals listed in the table, for example, are different from those in the similar table published by C&EN a year ago.

The list itself covers production figures for the U.S. and includes chemicals produced for export. Candidates for the list include all basic, intermediate, and chemically homogeneous finished products. These range from chemical building blocks such as ethylene and propylene to downstream products such as vinyl acetate and ethylene glycol.

The roster also includes basic inorganic chemicals, but does not include what C&EN considers to be minerals, such as salt, gypsum, and sulfur. Lime is included because it is processed and has many chemical and industrial applications. Refractory (dead-burned) dolomite is excluded in the calculations of lime production. This year potash is included for the first time.

In the organics list, such petrochemical feedstocks as ethane, butane, and propane are excluded arbitrarily, because they are considered to be products of oil companies and because they have many nonchemical uses.

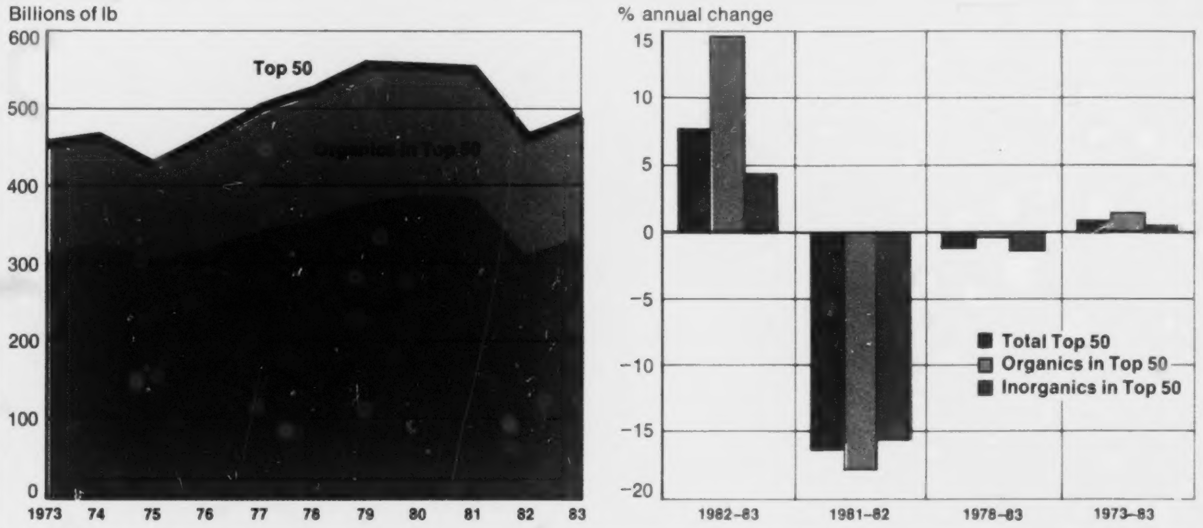
There are other gray areas besides lime and petrochemical feedstocks. For example, the basic aromatics—benzene, toluene, and xylene—are included. Admittedly, this makes the list less pure chemically.

Production figures are published by the government and trade associations in a variety of units—millions of pounds, thousands of tons, billions of cubic feet, millions of gallons, metric tons. To provide an accurate ranking and to make comparison of production volumes easier, C&EN not only gives production in common units but converts production to billions of pounds as well.

Top 50 chemical output rose for the first time in four years

Rank			Billions of lb		Common units[b]		Average annual growth			
1983	1982[a]		1983	1982	1983	1982	1982–83	1981–82	1978–83	1973–83
1	1	**Sulfuric acid**	69.45	65.36	34,725 tt	32,680 tt	6.3%	−19.7%	−3.3%	0.8%
2	2	**Nitrogen**	42.03	35.07	580 bcf	484 bcf	19.8	−1.2	8.2	9.8
3	5	**Lime**[c]	28.80	28.15	14,400 tt	14,075 tt	2.3	−25.5	−5.8	−3.2
4	4	**Oxygen**	28.73	28.81	347 bcf	348 bcf	−0.3	−19.3	−4.1	−1.1
5	6	**Ethylene**	28.59	24.50	28,586 mp	24,501 mp	16.7	−16.7	1.9	2.5
6	3	**Ammonia**	27.37	31.56	13,683 tt	15,778 tt	−13.3	−17.1	−4.5	−1.1
7	7	**Sodium hydroxide**	20.46	18.77	10,230 tt	9,385 tt	9.0	−9.9	−2.0	−0.5
8	8	**Chlorine**	19.92	18.35	9,960 tt	9,176 tt	8.5	−14.8	−2.1	−0.4
9	9	**Phosphoric acid**	19.90	16.52	9,950 tt	8,262 tt	20.4	−16.7	1.2	3.7
10	10	**Sodium carbonate**[d]	16.93	15.64	8,467 tt	7,819 tt	8.3	−5.6	4.6	1.2
11	11	**Nitric acid**	14.75	14.78	7,373 tt	7,390 tt	−0.2	−18.2	−1.5	−1.3
12	14	**Propylene**	13.98	12.54	13,984 mp	12,535 mp	11.6	−7.0	1.4	3.5
13	12	**Ammonium nitrate**[e]	13.24	14.18	6,618 tt	7,091 tt	−6.7	−19.3	−1.7	−0.9
14	13	**Urea**[f]	11.54	13.04	5,770 tt	6,518 tt	−11.5	−19.6	−1.7	5.2
15	16	**Ethylene dichloride**	11.25	7.62	11,247 mp	7,619 mp	47.6	−23.6	0.4	1.9
16	15	**Benzene**	9.48	7.75	1,287 mg	1,052 mg	22.3	−19.5	−2.9	−1.2
17	19	**Ethylbenzene**	7.86	6.66	7,857 mp	6,656 mp	18.0	−14.8	−1.3	3.3
18	18	**Carbon dioxide**[g]	7.15	7.36	3,574 tt	3,682 tt	−2.9	−2.9	2.4	8.6
19	21	**Toluene**[h]	7.12	5.18	981 mg	714 mg	37.4	−16.2	−1.4	0.2
20	20	**Styrene**	6.99	5.94	6,987 mp	5,942 mp	17.6	−11.0	−0.6	1.6
21	24	**Vinyl chloride**	6.95	4.90	6,950 mp	4,902 mp	41.8	−28.7	0.0	2.6
22	17	**Methanol**	6.62	7.56	6,624 mp	7,555 mp	−12.3	−11.9	0.6	−0.6
23	25	**Terephthalic acid**[i]	5.69	4.84	5,688 mp	4,843 mp	17.4	−22.3	−0.9	4.0
24	22	**Ethylene oxide**	5.58	4.99	5,575 mp	4,987 mp	11.8	−2.4	2.2	3.0
25	27	**Xylene**	5.57	4.74	773 mg	658 mg	17.5	−25.3	−1.8	−0.2
26	26	**Formaldehyde**[j]	5.40	4.82	5,398 mp	4,817 mp	12.1	−15.8	−3.3	−1.7
27	23	**Hydrochloric acid**	5.22	4.92	2,608 tt	2,460 tt	6.0	−1.7	−1.3	0.4
28	28	**Ethylene glycol**	4.46	4.31	4,460 mp	4,309 mp	3.5	4.0	2.7	3.1
29	31	***p*-Xylene**	4.11	3.21	4,109 mp	3,207 mp	28.1	−29.2	3.2	5.9
30	30	**Ammonium sulfate**	3.94	3.54	1,968 tt	1,768 tt	11.3	−16.2	0.3	−0.1
31	33	**Cumene**	3.30	2.74	3,304 mp	2,743 mp	20.5	−17.1	−0.5	2.2
32	29	**Potash**[k]	2.87	3.93	1,300 tmt	1,784 tmt	−27.1	−17.3	−10.4	−6.7
33	32	**Acetic acid**	2.79	2.75	2,794 mp	2,748 mp	1.7	−10.6	0.1	1.4
34	37	**Phenol**[l]	2.61	2.02	2,612 mp	2,023 mp	29.1	−21.5	−0.5	1.5
35	35	**Carbon black**	2.50	2.30	2,496 mp	2,302 mp	8.4	−15.7	−5.7	−3.3
36	38	**Butadiene**[m]	2.31	1.92	2,312 mp	1,915 mp	20.7	−35.9	−8.0	−4.4
37	34	**Aluminum sulfate**	2.29	2.37	1,144 tt	1,186 tt	−3.5	−8.3	−2.7	−0.7
38	36	**Acrylonitrile**	2.15	2.04	2,146 mp	2,035 mp	5.5	2.0	4.1	4.7
39	39	**Vinyl acetate**	1.96	1.88	1,962 mp	1,876 mp	4.6	−3.1	3.0	2.7
40	40	**Calcium chloride**[n]	1.88	1.75	942 tt	875 tt	7.7	−20.2	−1.8	−1.4
41	42	**Acetone**	1.87	1.69	1,873 mp	1,694 mp	10.6	−21.0	−5.8	−0.6
42	41	**Sodium sulfate**[o]	1.71	1.73	854 tt	864 tt	−1.2	−25.8	−6.1	−5.1
43	48	**Cyclohexane**	1.69	1.28	1,688 mp	1,275 mp	32.4	−29.9	−6.3	−2.3
44	43	**Propylene oxide**	1.58	1.48	1,581 mp	1,477 mp	7.0	−14.8	−5.0	−1.0
45	46	**Titanium dioxide**	1.51	1.31	757 tt	657 tt	15.2	−13.7	1.5	−0.4
46	45	**Sodium silicate**	1.45	1.33	726 tt	664 tt	9.3	−13.9	−2.6	0.0
47	49	**Adipic acid**	1.42	1.20	1,415 mp	1,197 mp	17.0	−1.1	−2.9	−1.1
48	47	**Sodium tripolyphosphate**	1.34	1.30	669 tt	651 tt	2.8	−6.5	−2.0	−3.6
49	44	**Isopropyl alcohol**	1.21	1.38	1,212 mp	1,380 mp	−12.2	−17.3	−6.9	−4.1
50	50	**Ethanol**	1.10	1.02	1,104 mp	1,023 mp	7.9	−22.3	−2.7	−5.6
TOTAL ORGANICS			165.17	143.96			14.7%	−17.9%	−0.1%	1.5%
TOTAL INORGANICS			333.41	319.04			4.5%	−15.6%	−1.5%	0.7%
GRAND TOTAL			498.58	463.00			7.7%	−16.3%	−1.0%	0.9%

a Revised. **b** tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons, tmt = thousands of metric tons. **c** Except refractory dolomite. **d** Synthetic and natural. **e** Original solution. **f** 100% basis. **g** Liquid and solid only. **h** All grades. **i** Includes both acid and ester without double counting. **j** 37% by weight. **k** K_2O basis. **l** Synthetic only. **m** Rubber grade. **n** Solid and liquid. **o** High and low purity. **Sources:** Bureau of the Census, Bureau of Mines, International Trade Commission, C&EN estimates



Production of basic chemicals bounced back in 1983

sample. In 1983, the board's basic chemicals output index climbed almost 12%. Its industrial production index for all chemicals and allied products rose 9.7%.

There are other differences between the 1983 recovery and that in 1976. In the earlier recovery year, production rose sharply enough to regain nearly all the ground lost in the 1975 slump. All the improvement of 1983, on the other hand, still leaves total output for the Top 50 chemicals well below the 1981 total. In fact, excepting 1982, it is necessary to go back to 1976 to find an annual production total lower than 1983's.

Still, for many individual chemical products, 1983 marked a sharp rebound in production. Ten of the Top 50, in fact, recorded growth of 20% or more over the previous year. The biggest gainer was ethylene dichloride, one of the bigger losers in 1982. EDC output rose 48% last year. Following in order of production increases were vinyl chloride, up 42%; toluene, up 37%; cyclohexane, up 32%; phenol, up 29%; *p*-xylene, up 28%; benzene, up 22%; butadiene, up 21%; cumene, up 21%; and phosphoric acid, up 20%.

The 10 chemicals with the worst output record in 1983 were potash, down 27%; ammonia, down 13%; methanol, down 12%; isopropyl alcohol, down 12%; urea, down 12%; ammonium nitrate, down 7%; aluminum sulfate, down 4%; carbon dioxide, down 3%; sodium sulfate, down 1%; and oxygen, down slightly. The preponderance of fertilizer materials on the list reflects last year's drought and payment-in-kind (PIK) program. The industrial gases on the list were hurt by the poor performance of the U.S. steel producing industry.

Analysis of long-term production trends, on the other hand, spotlights a number of different chemical products. Over the past 10 years, for example, the fastest-growing products have been industrial gases. Of these, nitrogen has grown the most, with nearly a 10% annual compound growth rate between 1973 and 1983. Not only did nitrogen output increase just under 20% last year, its 1.2% decline in the 1982 recession was one of the lowest in the Top 50 group.

Close behind nitrogen in long-term performance is carbon dioxide, production of which grew at a 9% annual compound rate over the past 10 years. Unlike nitrogen, however, which grew during the recession-racked 1978–83 period almost as fast as during the 10-year span, carbon dioxide production increased at an annual rate of just 2% over the past five years. In each of the past two years, production decreased nearly 3%.

The other top chemicals in terms of production growth over the past decade are *p*-xylene, up 6% a year; urea, up 5% a year despite its dismal performance over the past two years; acrylonitrile, up 5% a year; terephthalic acid, phosphoric acid, and propylene, each up 4%; and ethylbenzene, ethylene glycol, and ethylene oxide, each up 3%.

There are probably no surprises in the list of the five worst performers since 1973. Potash production has shrunk at an annual compound rate of nearly 7% over the decade. Ethanol output has declined 6% a year. Following are sodium sulfate, down 5% a year; butadiene, down 4% a year; and isopropyl alcohol, down 4% a year.

The unevenness of the recovery last year resulted in only a few noticeable changes in the ranking of the Top 50 chemicals. Lime moved from fifth to third position, and ammonia fell from third to sixth. Vinyl chloride jumped from 24 to 21; potash dropped from 29 to 32. Cyclohexane shot up from 48 in 1982 to 43 last year, whereas isopropyl alcohol dropped from 44 to 49. Ethanol retained its grasp on 50th place, and sulfuric acid remained unchallenged in first place. ☐

Profits up for largest chemical producers

To 50 *Chemical Producers*

William J. Storck, C&EN New York

The fortunes of the chemical industry were buoyed tremendously by the economy in general last year as two industries that provide markets for chemical end products—housing and autos—finally got back on track. Housing picked up once again as interest rates declined, making mortgages once again affordable. And the declining interest rates and the aging automobile population gave new life to the auto industry—a resurgence that is continuing into 1984 as auto makers are reporting their highest profits in years.

The result of these upturns was increased demand for fibers and plastics, two big contributors to the fortunes of the chemical industry.

The one nagging problem that remained throughout the year for many U.S. chemical producers was in agricultural chemicals. Many manufacturers of pesticides and almost all fertilizer makers suffered in 1983 because of the government's payment-in-kind (PIK) program to pull crop acreage out of production. The result of this program was evident in many companies such as W. R. Grace, Stauffer Chemical, Williams Cos., and Eli Lilly, all of which had declining chemical operating profits if not outright deficits.

The year was good enough, however, that 32 of 49 companies on C&EN's list of the 50 largest chemical producers (in terms of chemical sales) posted sales gains in 1983 over 1982. (Stauffer was excluded because, during the year, it changed its fiscal year and did not restate prior data to reflect the change, making comparisons meaningless if not impossible.) In last year's listing, every company on the list recorded a sales decline in 1982 from the previous year.

Combined 1983 chemical sales for the Top 50 companies (excluding Stauffer) increased 6.3% over 1982 to $101 billion. Most striking, however, is that operating profits (sales minus administrative expenses and costs of selling) for chemicals for the companies reporting such data increased 87% from 1982 to $6.60 billion. As a result, operating profit margins for the group increased to 6.7% from 3.8% the year before.

Once again, Du Pont won the honor of being the U.S.'s largest chemical producer, with $11.6 billion in chemical sales in 1983, up about 33% from 1982. The second to fifth largest producers retained the same ranking as last year and were, respectively, Dow Chemical, with $8.88 billion in chemical sales; Exxon, with $8.44 billion; Monsanto, with $5.77 billion; and Union Carbide, with $3.91 billion.

Most of the companies in the Top 50 gained or slipped a notch or two in this year's ranking, but a few shifted more dramatically. For instance, Mobay rose to 22 from 30 last year, and Goodrich rose to 30 from 34. On the other hand, sales declines sent some companies lower on this year's list, including Phillips Petroleum to 14 from 10 last year, and Williams Cos. to 45 from 40.

Three companies are new to the Top 50 ranking this year. Borg-Warner moved up to 40th place in 1983 from 52 among chemical manufacturers in 1982. Georgia-Pacific also rose in rank to 47 from 51 last year, and Badische moved up to 48 from 57.

Likewise, three companies dropped off the list, but none because of declining sales. El Paso was acquired by Occidental Petroleum and Getty by Texaco. Tenneco was dropped from the list because it now lumps its much diminished chemical operations in with its refining and marketing operations, giving a picture of sales at least three to four times what they actually are. Tenneco might have dropped out of the Top 50 ranking anyway, after selling much of its chemical operations. If the other two companies had been able to report their results, Nalco Chemical and Merck certainly would not have been on the Top 50 list this year.

Other large chemical producers aren't included on the list, because they do not break out chemical sales in a manner that gives an honest picture of their operations. Chief among these is General Electric, for which as much as 10% of its total 1983 sales of $26.8 billion may be in chemical and plastics markets. Procter & Gamble, with its huge operations in detergent chemicals, also falls into this group. Then, too, there are some companies such as Texasgulf and Akzona that, because of acquisition by foreign firms, no longer report chemical sales in the U.S.

Even the companies on the Top 50 list are not pure in reporting their chemical sales. Many of the companies include large amounts of nonchemical products in the chemical breakouts. On the other side of the coin are companies that do not give a complete report of all of their chemical sales in their financial reports. PPG Industries certainly would rank higher than it does if all chemical sales were broken out. And Witco Chemical probably would make the Top 50 listing if some of its chemical sales were not hidden in other divisions. Probably the best example of this, however, is Occidental Petroleum. Occidental lumps its huge fertilizer operations into a business segment called Agribusiness, which also includes its even larger slaughterhouse operations. □

Chemical sales, earnings increase for most top U.S. producers

Rank 1983	Rank 1982[a]	Company	Chemical sales 1983 ($ millions)	Change from 1982	Chemical sales as % of total sales	Industry classification	Chemical operating profit 1983[b] ($ millions)	Change from 1982	Chemical operating profits as % of total operating profit	Operating profit margin[c]	Chemical assets 1983	Chemical assets as % of total assets	Operating return on chemical assets[d]
1	1	**Du Pont**	$11,607	6.4%	32.8%	Diversified	$1144	171.7%	26.2%	9.9%	$7591	31.1%	15.1%
2	2	**Dow Chemical**	8,875	8.1	81.0	Basic chemicals	573	153.5	111.0	6.5	8193	68.4	7.0
3	3	**Exxon**	8,439	39.5	7.5	Petroleum	348	640.4	3.9	4.1	4852	7.9	7.2
4	4	**Monsanto**	5,771[e]	11.8	92.6	Basic chemicals	568	8.4	102.3	9.8	4498	70.0	12.6
5	5	**Union Carbide**	3,912	−2.5	43.5	Basic chemicals	285	108.0	42.0	7.3	4917	47.8	5.8
6	7	**Celanese**	3,261	6.5	100.0	Basic chemicals	214	448.7	100.0	6.6	2869	100.0	7.5
7	6	**Shell Oil**	3,227	4.6	16.4	Petroleum	130	def	4.2	4.0	3759	17.0	3.5
8	8	**Standard Oil (Ind.)**	2,906	4.3	9.9	Petroleum	173	30.1	4.8	6.0	2445	9.6	7.1
9	9	**W. R. Grace**	2,760	5.3	44.4	Specialty chemicals	324	3.5	62.3	11.7	1641	32.6	19.7
10	11	**Atlantic Richfield**	2,550	13.8	9.8	Petroleum	64	def	2.4	2.5	2603	11.2	2.5
11	14	**Allied**	2,337	9.1	23.3	Diversified	224	69.7	20.3	9.6	1299	17.0	17.2
12	13	**Mobil**	2,331	8.5	4.0	Petroleum	−16	def	def	def	2266	6.5	def
13	12	**Eastman Kodak**	2,285	6.2	22.5	Photo equipment	214	4.4	20.8	9.4	2124	19.4	10.1
14	10	**Phillips Petroleum**	2,255	−4.3	14.8	Petroleum	83	260.9	3.2	3.7	1413	10.8	5.9
15	15	**Hercules**	2,007	−1.6	76.3	Basic chemicals	121	61.3	66.1	6.0	1204	55.4	10.0
16	17	**Rohm & Haas**	1,808	4.7	96.4	Basic chemicals	298	91.0	108.8	16.5	1038	68.7	28.7
17	16	**Gulf Oil**	1,748	−12.9	6.2	Petroleum	−76	def	def	def	1009	4.8	def
18	18	**American Cyanamid**	1,719	1.3	48.6	Basic chemicals	106	6.0	36.5	6.2	1275	41.7	8.3
19	20	**Ethyl**	1,478[e]	4.7	84.7	Basic chemicals	156	2.6	84.1	10.6	901	83.4	17.3
20	21	**Air Products[f]**	1,412	3.9	86.4	Basic chemicals	196	2.4	96.2	13.9	1654	74.5	11.8
21	19	**Stauffer Chemical**	1,340	nm	100.0	Basic chemicals	−14	def	def	def	2048	100.0	def
22	30	**Mobay**	1,300	15.0	100.0	Basic chemicals	66[h]	def	100.0	5.1	na	na	na
23	22	**FMC**	1,296	−1.8	37.0	Machinery	169	13.3	61.3	13.0	1063	38.2	15.9
24	25	**Borden**	1,295[e]	6.2	30.4	Dairy products	138	60.9	37.3	10.6	1325	48.7	10.4
25	23	**Ciba-Geigy**	1,290	0.3	65.1	Specialty chemicals	na	na	na	na	na	na	na
26	28	**American Hoechst**	1,222[e]	3.0	75.2	Basic chemicals	na	na	na	na	na	na	na
27	27	**Ashland Oil**	1,208	0.9	14.9	Petroleum	1	−96.4	0.5	0.1	423	10.3	0.2
28	40	**Occidental Petroleum**	1,137[g]	−10.1	5.8	Petroleum	−12	def	def	def	985	8.4	def
28	26	**Texaco**	1,137	−6.1	2.8	Petroleum	−65	def	def	def	895	3.3	def
30	34	**B. F. Goodrich**	1,133	11.6	35.5	Rubber products	44	3927.3	43.9	3.9	1214	47.1	3.6
30	29	**Unocal Corp.**	1,133	−1.7	10.7	Petroleum	74[h]	−17.3	11.8	6.5	699	7.6	10.6
32	31	**U.S. Steel**	1,128	4.7	6.4	Steel	−27	def	def	def	1130	5.9	def
33	36	**Olin**	1,111	9.7	57.4	Basic chemicals	68	21.5	44.9	6.1	1002	54.8	6.8
34	32	**Standard Oil of Calif.**	1,059	1.1	3.7	Petroleum	−12[h]	def	def	def	780	3.8	def
35	38	**BASF Wyandotte**	1,034	15.6	100.0	Basic chemicals	20	def	100.0	1.9	726	100.0	2.7
36	35	**International Minerals[i]**	997	−1.6	68.2	Agrichemicals	156	−7.6	81.1	15.7	1377	70.8	11.4
37	33	**Diamond Shamrock**	942	−9.0	23.4	Petroleum	12	−83.2	def	1.3	1063	17.6	1.1
38	39	**PPG Industries**	882	−1.2	24.0	Glass products	51	30.8	11.8	5.8	1152	31.9	4.4
39	37	**CF Industries**	862[e]	−6.2	100.0	Agrichemicals	34	def	100.0	4.0	1013	100.0	3.4
40	52	**Borg-Warner**	826	34.8	23.5	Auto equipment	110	112.7	35.2	13.3	365	13.9	30.2
41	41	**Lubrizol**	800	−1.5	100.0	Specialty chemicals	109	5.1	100.0	13.6	683	100.0	15.9
42	44	**National Distillers**	785	14.6	30.3	Alcoholic beverages	68	86.5	41.6	8.6	683	34.6	9.9
43	46	**Dow Corning**	763	15.1	100.0	Specialty chemicals	68[h]	29.1	100.0	9.0	na	na	na
44	43	**Reichhold Chemicals**	747	−5.0	100.0	Basic chemicals	35	137.9	100.0	4.6	371	96.4	9.3
45	40	**Williams Cos.**	740	−10.7	34.1	Agrichemicals	1	def	0.6	0.1	894	19.1	0.1
46	42	**Eli Lilly**	727	−7.8	24.0	Drugs	98	−33.4	12.4	13.5	793	837.8	12.3
47	51	**Georgia-Pacific**	683	8.8	10.6	Wood products	64	−16.9	61.0	9.4	1023	20.5	6.3
48	57	**Badische**	671	33.9	100.0	Basic chemicals	30	def	100.0	4.4	513	100.0	5.7
49	47	**Nalco Chemical**	659	2.4	100.0	Specialty chemicals	118	19.0	100.0	17.8	489	100.0	24.0
50	49	**Merck**	606	−5.1	18.7	Drugs	52	−11.7	7.3	8.6	592	14.0	8.8

a Revised. **b** Operating profit defined as sales less administrative expense and cost of selling. **c** Operating profit as a percentage of chemical sales. **d** Operating profit as a percentage of identifiable chemical assets. **e** Chemical sales include significant amounts of nonchemical products. **f** Fiscal year ended Sept. 30, 1983. **g** Does not include all chemical products. **h** Chemical net profits. **i** Fiscal year ended June 30, 1983. **na** = not available. **nm** = not meaningful. **def** = deficit.

als trained in a broader, more varied range of professional disciplines so that the collective brain of the corporation can cope with this more complex world that we live in.

C&EN: Are you acting upon this at Air Products?

Donley: Yes. We are. It's a cultural change that we're forcing upon ourselves. I talked to a group of engineers here not long ago, and one guy said, "Donley wants us to hire flute players," which was intended as a joke, but which nevertheless showed a sort of bias in favor of the engineering discipline. Now I'm an engineer myself, so I'm not going to put down the importance of engineering and technology, but that's not enough for the future.

C&EN: Looking back on the past, there's always been this alternating love-hate relationship between business and liberal arts people. Is this just the cycle coming around again, or is there something new here?

Donley: I think there's something new in that the external conditions in the world are different. To be able to make expert, intelligent judgments about the future both here at home and in the markets we serve overseas, we have to understand those cultures and political systems and economic systems and so forth to a greater extent than we had to before. I know there's always been this, as you call it, love-hate relationship: C. P. Snow called it the "two cultures." The world won't permit us to thrive anymore unless we meld these two cultures together.

C&EN: During the past recession, many companies reduced their market research effort. What have you done?

Donley: Our market research has expanded. I think reducing it is a fatal mistake. There are certain things that we think you have to believe in like religion. One is research—both physical and market—and the other is human resources recruiting. People have a tendency to open and close those valves depending on outside economic conditions. We think that's really adverse to the long-term vitality of the company. We haven't cut back the effort or the commitment.

Maybe I see a silver lining in a dark cloud, but I think this recession taught U.S. management to look more rigorously at what we're doing—whether we are, in fact, responding to markets with enough insight and sensitivity, whether we have become bureaucratic in our companies, whether we have more layers of management than we need. Certainly here at Air Products we have had forced upon us by the economic conditions a heightened sensitivity in those regards. We've learned from the recession. □

Stock maneuverings are rife in chemicals

During the first four months of this year, a broad range of chemical companies have been attempting to repurchase large amounts of their own common and preferred stock. Other companies have increased the authorized number of common shares or added authorization for new classes of preferred stock. Still others have arranged to sell new stock to exchange for debt.

The active deployment of stock for financial and other purposes continues a trend begun last year. Such repurchases typically are made to cover employee stock option plans. When stock prices are considered low, as many chemical stocks now are, companies may repurchase shares as an investment. Since reducing the number of outstanding shares automatically raises earnings per share, companies also may make such moves in an effort to shore up the price of their stock. Repurchasing stock and increasing the number of authorized but not issued preferred shares can buttress a corporation's defenses against an unwelcome takeover bid as well.

In new programs announced recently, such firms as American Cyanamid, Celanese, Chemed, Church & Dwight, Dart & Kraft, Loctite, Olin, SmithKline Beckman, and Stauffer Chemical made offerings to rebuy common stock. Allied, Koppers, Reichhold Chemicals, and Sherwin-Williams announced they would repurchase preferred shares.

Nalco Chemical quadrupled its authorized number of preferred shares to 2 million and common stock from 60 million to 100 million. Owens-Corning Fiberglas doubled its authorized common stock pool to 100 million shares and approved a new class of 8 million shares of preferred stock.

In equity-for-debt swaps, Borg-Warner moved to sell up to 350,000 new shares of common stock to exchange for a $6.1 million promissory note held by Goldman Sachs, and Reichhold will issue up to 350,000 new shares of common stock or pay cash in exchange for debt.

David Webber, New York

Stock repurchase continues apace in early 1984

	Number of shares	Value[a] ($ millions)
REPURCHASING COMMON STOCK		
American Cyanamid	500,000	$ 24.0
Celanese	750,000	53.8
Chemed[b]	171,000[a]	6.0
Church & Dwight	250,000	5.6
Dart & Kraft	5,000,000	347.5
Loctite	500,000	18.0
Olin[c]	1,000,000	29.1
SmithKline Beckman[d]	3,000,000	162.8
Stauffer Chemical	700,000	13.8
REPURCHASING PREFERRED STOCK		
Allied	e	150.0
Koppers[f]	500,000	51.0
Reichhold Chemicals	g	g
Sherwin-Williams[h]	10,500	1.1

a Based on approximate market value of shares at time of announcement. b Since 1980, company has spent $7.5 million on stock repurchase. New authorization is in addition to previous program. c Repurchased 175,000 "odd-lot" shares in December and January in offer to buy 600,000 such shares. d In addition to 3 million share repurchase program authorized in January. e Will be made on open market or through private transactions. Company previously repurchased $148 million of these shares. f In 1983 and first-quarter 1984, company repurchased 190,400 shares of total 559,600 outstanding. g Will repurchase at discount from $100 stated value. h Redemption price is $100 per share plus accrued dividends.

Urbana, Chapel Hill top graduate rankings

The University of Illinois, Urbana-Champaign, has regained its almost traditional position as the largest producer of new Ph.D. chemists in this country. And the University of North Carolina, Chapel Hill, remains the leading producer of bachelor's degree chemistry graduates.

These are two of the findings gleaned by C&EN from the latest annual report by ACS's Committee on Professional Training. The report, which is presented in full starting on page 44, covers the 1982–83 academic year. CPT is the mechanism through which ACS monitors, and sets standards for, chemistry undergraduate programs.

Urbana-Champaign has been the largest producer of Ph.D. chemists for eight of the past 10 years. It yielded to the University of California, Berkeley, which is second on the latest listing, in 1979–80 and 1981–82.

Chapel Hill has been even more dominant, being the largest producer of new bachelor chemistry graduates for nine of the past 10 years. In 1979–80 it yielded to Indiana University. Indiana has remained in the second position since.

The University of Michigan, Ann Arbor, is the new leader of the list of producers of certified bachelor graduates. It displaces Rutgers University, New Brunswick. The University of California, San Diego, headed this list for the previous eight years. Certified graduates have completed a curriculum certified by CPT and are immediately eligible for ACS membership.

The new report also sheds light on the growing penetration of the chemical profession by women over the past decade. In 1982–83, 33% of new bachelor's degree chemists were women. This is up from 18% 10 years earlier. The corresponding figures for new Ph.D. chemists are 17% and 10%. The gains in chemical engineering have been relatively even greater. In 1982–83, 23% of new bachelor's degree chemical engineers were women. This compares with 3% in 1972–73. ◻

These schools had the most chemistry graduates, 1982–83

Total bachelor graduates	
1. U of North Carolina, Chapel Hill	136
2. Indiana U, Bloomington	120
3. U of Illinois, Urbana-Champaign	113
4. U of California, Los Angeles	109
5. Emory U	108
6. U of Miami	96
7. U of Pittsburgh	95
8. U of Maryland, College Park	89
9. U of Washington	77
10. Duke U	76
11. U of Michigan, Ann Arbor	75
12. U of South Florida	74
13. U of Virginia	72
14. U of Florida	71
15. Miami U	67
16. U of California, Berkeley	64
16. U of Colorado, Boulder	64
18. U of Georgia	63
19. U of California, San Diego	59
19. U of Puerto Rico, Rio Piedras	59
21. Rutgers U, New Brunswick	58
22. State U of New York, Stony Brook	57
22. U of Texas, Austin	57
24. Youngstown State U	56
25. Cornell U	53

Certified bachelor graduates	
1. U of Michigan, Ann Arbor	75
2. U of California, Berkeley	60
3. U of California, San Diego	59
3. U of Washington	59
5. U of Texas, Austin	57
6. U of Illinois, Urbana-Champaign	51
7. Rutgers U, New Brunswick	46
8. U of California, Los Angeles	44
9. Illinois State U	41
10. U of North Carolina, Chapel Hill	40
11. Massachusetts Inst. of Tech	39
12. U of California, Davis	37
13. U of Delaware	35
14. Rensselaer Polytechnic Inst.	34
15. C of William & Mary	32
16. U of California, Santa Cruz	30
16. Miami U	30
16. Texas A&M U	30
19. C of the Holy Cross	29
19. Purdue U	29
21. Arizona State U	28
21. U of Arizona	28
21. Indiana U, Bloomington	28
24. Carnegie-Mellon U	27
24. Cornell U	27
24. Michigan State U	27
24. Ohio State U	27
24. U of Vermont	27

Masters graduates	
1. Cornell U	45
2. Princeton U	33
3. U of Illinois, Chicago	26
3. Northwestern U	26
3. U of Rochester	26
3. Yale U	26
7. U of Arizona	22
8. U of Scranton	21
9. U of Michigan, Ann Arbor	20
10. California State U, Long Beach	18
10. U of California, San Diego	18
10. U of Illinois, Urbana-Champaign	18
13. U of Cincinnati	17
13. Columbia U	17
13. U of Washington	17
16. New York U	16
17. U of Pittsburgh	15
18. Stevens Institute of Tech	14
18. Villanova U	14
18. Wright State U	14
21. Michigan State U	13
21. Seton Hall U	13
23. U of California, Berkeley	12
23. U of Florida	12
23. U of Georgia	12
23. Indiana U, Bloomington	12

Doctoral graduates	
1. U of Illinois, Urbana-Champaign	66
2. U of California, Berkeley	58
3. Massachusetts Inst. of Tech	41
4. U of Wisconsin, Madison	37
5. Purdue U	34
6. Michigan State U	33
7. U of North Carolina, Chapel Hill	32
8. Indiana U, Bloomington	29
8. Texas A&M U	29
10. U of California, Los Angeles	28
10. U of California, San Diego	28
12. U of Florida	27
12. Harvard U	27
12. Ohio State U	27
15. Yale U	26
16. California Institute of Tech	25
17. U of Arizona	24
17. U of Cincinnati	24
17. U of Texas, Austin	24
20. U of Chicago	23
20. Cornell U	23
20. U of Nebraska, Lincoln	23
20. Pennsylvania State U	23
24. Iowa State U	22
24. U of Massachusetts	22

ACS Committee on Professional Training 1983 Annual Report

The number of bachelor's degree graduates in chemistry from colleges and universities whose undergraduate chemistry programs are approved by the American Chemical Society increased 1.8% in the 1982–83 academic year from the previous year. The number of master's degrees from these departments decreased 4.6%, and the number of Ph.D. degrees continued to rise for the fourth year in a row, this year 4.5%.

The percentage of baccalaureate graduates certified by ACS was again 42%. (Certified graduates are those who have completed the curriculum specified by the Committee on Professional Training and are eligible for full membership in ACS; noncertified graduates may become associate members of ACS upon graduation and full members after three years of professional experience or a higher degree in chemical science.)

A total of 2473 of the bachelor's degree graduates from the approved schools were reported as planning to go to graduate school, and 1973 reported plans to go to professional schools.

Total numbers of bachelor's degrees (certified and noncertified), master's degrees, and Ph.D. degrees awarded in 1982–83 by departments whose chemistry programs are ACS approved are listed by institution in the large table at the end of this report and are summarized in the two smaller tables. These tables also include numbers of chemical engineering graduates from institutions whose programs are accredited by the American Institute of Chemical Engineers and the Accreditation Board for Engineering & Technology. (Note: Those departments are not required to report their data to CPT, so the number of departments included varies each year.) Included for the second year is a table with information on graduate student enrollments in chemistry departments whose undergraduate programs are ACS approved.

Fall 1982 grad student enrollments in departments whose undergraduate chemistry programs are ACS approved

	Number of departments	First-year graduate students Full time	First-year graduate students Part time	All graduate students Full time	All graduate students Part time
M.S. departments[a]	131	494	310	1,075	1048
Ph.D. departments	189	3412	306	13,488	1483
TOTAL	**320**	**3906**	**616**	**14,563**	**2531**

a Departments whose highest offering is the master's degree in chemistry

Summary of totals from 1983 reports from approved programs

	Schools reporting	Men	Women	Total
CHEMISTRY				
Bachelors, total	570	6731	3312	10,043
Certified		2842	1391	4,233
Noncertified		3889	1921	5,810
Masters	320	1125	444	1,569
Doctorates	189	1459	300	1,759
CHEMICAL ENGINEERING				
Bachelors, certified	122	5409	1612	7,021
Masters	116	1153	164	1,317
Doctorates	101	314	19	333

The number of bachelor's degrees in chemical engineering from the 122 AIChE-ABET-accredited departments that reported in 1983 increased 17.7% from the total reported by 113 departments in 1982. These 122 departments reported an expected further increase of 4.9% in 1984. During the five-year period 1979–83, the number of reported bachelor's degree graduates in chemical engineering increased 41%. At the graduate level, the number of chemical engineering master's degrees reported in 1983 rose 12.5% from the year before, and the number of Ph.D. degrees reported increased 13.7%.

Programs at ACS-approved departments normally are re-evaluated at five-year intervals. There were 572 colleges and universities on the approved list at the end of 1983. During the year, the committee studied the chemistry programs of 182 of the approved schools and of 20 schools applying for ACS approval. Each evaluation involved a review of extensive documentary materials submitted by the department chair describing the status of the program.

During 1983 eight chemistry programs were newly approved by the

Committee members, 1983

Henry A. Bent, *chairman*
North Carolina State University
J. Arthur Campbell
Harvey Mudd College
Marjorie C. Caserio
University of California, Irvine
Alice J. Cunningham
Agnes Scott College
Ernest L. Eliel
University of North Carolina, Chapel Hill
Harry B. Gray
California Institute of Technology
C. David Gutsche
Washington University
Peter Lykos
Illinois Institute of Technology
Eli M. Pearce
Polytechnic Institute of New York
Jere P. Segrest
University of Alabama, Birmingham
Shalaby W. Shalaby
Ethicon Inc.
Richard P. Van Duyne
Northwestern University
Melvin B. Robin (consultant)
Bell Telephone Laboratories
Bonnie R. Blaser, *secretary*
Mairin B. Brennan, *staff associate*
American Chemical Society

committee and four approved programs were put on probation. No departments were removed from the approved list in 1983.

During the past several years the committee has been involved in revising its guidelines for evaluating undergraduate chemistry programs, and comments and suggestions on several drafts of this revision were requested from the ACS-approved schools, the ACS divisions, the committee's visiting associates, and other interested individuals. After receiving many suggestions, not all of them compatible with each other, the committee completed its work on this revision, and the new guidelines were published in October 1983.

To determine why chemistry faculty members leave for other positions, especially nonacademic ones, the committee conducted a survey in 1980 on faculty mobility the past 10 years (1970–79) in ACS-approved departments. To identify trends, followup surveys were conducted for 1980, 1981, and 1982. The committee plans to review the results from these surveys, as well as from the 1983 survey (for which data are being collected this spring and summer) to determine whether any noteworthy trends are indicated.

The 1983 ACS Directory of Graduate Research included for the first time programs in polymer science and clinical chemistry in addition to the chemistry, chemical engineering, biochemistry, and pharmaceutical/medicinal chemistry programs included in previous editions. This biennial publication of the committee provides guidance information for students who are considering graduate education in chemistry and related fields. The directory includes M.S. and Ph.D. degree-granting departments in the above specialties in the U.S. and Canada. Included in each department's listing are biographical information on faculty members, their research interests, and titles of their publications for a two-year period.

Summary of data from approved programs, 1979–83

	Bachelors				Masters		Doctorates	
	Number of schools	Graduates (totals)	Certified graduates	Non-certified graduates	Number of schools	Graduates	Number of schools	Graduates
CHEMISTRY								
1979	551	10,451	4424	6027	323	1716	188	1532
1980	554	10,170	4170	6000	324	1698	188	1561
1981	558	10,453	4337	6116	323	1609	187	1613
1982	561	9,866	4179	5687	322	1645	187	1683
1983	570	10,043	4233	5810	320	1569	189	1759
CHEMICAL ENGINEERING[a]								
1979	112	4,977	4977	—	107	951	92	237
1980	109	5,348	5348	—	105	974	88	243
1981	110	5,831	5831	—	106	1020	87	250
1982	113	5,963	5963	—	109	1171	92	293
1983	122	7,021	7021	—	116	1317	101	333

a Chemical engineering departments are not required to report their data to CPT, so the number of departments included in this category varies from year to year. **Note:** Bachelor's degree projections for 1984: 570 chemistry departments report that they expect a total of 10,819 bachelor's degree graduates with majors in chemistry during the 1983–84 academic year, and 122 chemical engineering departments report that they expect a total of 7364 bachelor's degree graduates with majors in chemical engineering.

Progress continued on the preparation of a computerized database that will consist of all information included in the 1983 directory as well as a multidimensional concordance of the research interests of the faculty members listed in this edition. It is expected that this database will be available on-line through a commercial vendor (Bibliographic Retrieval Services) later this spring.

The committee would like to acknowledge and thank the following visiting associates of the committee who conducted on-site visits to schools on the approved list or applying for ACS approval during 1983: David S. Breslow, Wilmington, Del.; David W. Brooks, University of Nebraska; Robert B. Carlin, Carnegie-Mellon University; Phillip L. Certain, University of Wisconsin, Madison; David M. Hercules, University of Pittsburgh; Ronald C. Johnson, Emory University; William R. Moomaw, Williams College; Robert A. Pierotti, Georgia Institute of Technology; Richard W. Ramette, Carleton College; Riley Schaeffer, University of New Mexico; and Richard C. Schoonmaker, Oberlin College.

Chemistry and chemical engineering degrees awarded by approved schools, 1982–83

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Abilene Christian U	6	2	4	—	—	—	—
Adelphi U	2	8	0	—	—	—	—
Agnes Scott C	6	0	—	—	—	—	—
Akron, U of	13	8	6	3	a	—	—
Alabama, U of							
University	4	17	2	6	42	6	2
Birmingham	4	6	2	1	—	—	—
Huntsville	3	3	2	—	—	—	—
Alaska, U of	7	1	1	—	—	—	—
Albion C	3	12	—	—	—	—	—
Albright C	8	15	—	—	—	—	—
Alfred U	9	0	—	—	—	—	—
Allegheny C	4	29	—	—	—	—	—
Alma C	2	8	—	—	—	—	—
American U	10	5	2	6	—	—	—
Amherst C	4	13	—	—	—	—	—
Andrews U	3	4	—	—	—	—	—
Appalachian State U	1	10	2	—	—	—	—
Arizona State U	28	12	0	14	43	7	0
Arizona, U of	28	6	22	24	30	6	0
Arkansas, U of							
Fayetteville	11	14	1	13	36	12	1
Little Rock	3	8	2	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Ashland C	0	2	—	—	—	—	—
Auburn U	2	33	3	2	81	5	2
Augsburg C	4	3	—	—	—	—	—
Augustana C (Illinois)	1	12	—	—	—	—	—
Augustana C (South Dakota)	1	7	—	—	—	—	—
Austin C	3	8	—	—	—	—	—
Baldwin-Wallace C	1	11	—	—	—	—	—
Ball State U	5	1	5	—	—	—	—
Barnard C	5	14	—	—	—	—	—
Bates C	10	7	—	—	—	—	—
Baylor U	9	20	3	2	—	—	—
Beloit C	0	20	—	—	—	—	—
Bemidji State U	3	4	—	—	—	—	—
Birmingham-Southern C	6	24	—	—	—	—	—
Bloomsburg U	2	4	—	—	—	—	—
Boston C	10	21	3	2	—	—	—
Boston U	9	20	5	5	—	—	—
Bowdoin C	5	32	—	—	—	—	—
Bowling Green State U	6	17	5	—	—	—	—
Bradley U	3	11	0	—	—	—	—
Brandeis U	2	13	3	11	—	—	—
Bridgeport, U of	3	0	5	—	—	—	—
Bridgewater State C	2	12	0	—	—	—	—
Brigham Young U	19	28	3	4	51	8	1
Brown U	7	12	1	15	—	—	—
Bryn Mawr C	19	0	1	1	—	—	—
Bucknell U	14	12	3	—	23	5	—
Butler U	3	9	3	—	—	—	—
California Institute of Tech	7	8	6	25	13	6	5
California Polytechnic State U	9	30	0	—	—	—	—
California State C							
Bakersfield	7	2	—	—	—	—	—
San Bernardino	2	7	—	—	—	—	—
Stanislaus	1	0	—	—	—	—	—
California State Polytechnic U	7	3	4	—	45	—	—
California State U							
Chico	1	12	—	—	—	—	—
Dominguez Hills	3	4	—	—	—	—	—
Fresno	6	7	4	—	—	—	—
Fullerton	10	11	4	—	—	—	—
Hayward	8	13	1	—	—	—	—
Long Beach	9	23	18	—	46	—	—
Los Angeles	10	1	3	—	—	—	—
Northridge	8	15	4	—	—	—	—
Sacramento	8	4	8	—	—	—	—
California, U of							
Berkeley	60	4	12	58	141	23	16
Davis	37	8	6	19	59	16	3
Irvine	12	40	8	10	—	—	—
Los Angeles	44	65	11	28	—	—	—
Riverside	19	2	11	11	—	—	—
San Diego	59	0	18	28	—	—	—
Santa Barbara	24	9	6	13	35	5	2
Santa Cruz	30	15	5	6	—	—	—
Calvin C	5	5	—	—	—	—	—
Canisius C	7	8	—	—	—	—	—
Capital U	0	4	—	—	—	—	—
Carleton C	2	30	—	—	—	—	—
Carnegie-Mellon U	27	0	8	4	77	11	10
Carroll C	2	7	—	—	—	—	—
Carthage C	1	4	—	—	—	—	—
Case Western Reserve U	9	36	8	10	40	8	2
Catholic U of America	1	1	0	2	a	—	—
Centenary C of Louisiana	0	5	—	—	—	—	—
Central C	0	9	—	—	—	—	—
Central Connecticut State U	3	0	3	—	—	—	—
Central Florida, U of	12	0	3	—	—	—	—
Central Michigan U	3	14	10	—	—	—	—
Central State U (Ohio)	2	1	—	—	—	—	—
Central State U (Oklahoma)	1	15	—	—	—	—	—
Charleston, C of	10	5	—	—	—	—	—
Chatham C	1	1	—	—	—	—	—
Chestnut Hill C	5	4	—	—	—	—	—
Chicago, U of	4	26	3	23	—	—	—
Cincinnati, U of	19	0	17	24	58	9	1
Citadel, The	0	12	—	—	—	—	—
City U of New York							
Graduate Center	—	—	—	12	—	—	—
Brooklyn C	0	34	0	—	—	—	—
City C	1	12	3	—	a	—	—
Herbert H. Lehman C	2	7	—	—	—	—	—
Hunter C	2	5	—	—	—	—	—
Queens C	2	17	4	—	—	—	—
Clarion U of Pennsylvania	3	3	—	—	—	—	—
Clark U	15	3	1	1	—	—	—
Clarkson C of Tech	16	0	1	4	114	9	4
Clemson U	5	4	2	3	65	11	0
Cleveland State U	14	0	7	6	46	2	3
Coe C	1	8	—	—	—	—	—
Colby C	5	13	—	—	—	—	—
Colgate U	4	7	—	—	—	—	—
Colorado C	9	2	—	—	—	—	—
Colorado School of Mines	7	0	9	5	90	6	1
Colorado State U	11	8	2	13	23	4	0
Colorado, U of							
Boulder	25	39	4	21	72	9	2
Denver	2	12	1	—	—	—	—
Columbia U	9	0	17	20	42	36	6
Concordia C	1	10	—	—	—	—	—
Connecticut, U of	12	24	6	1	59	6	2
Cooper Union[b]	—	—	—	—	25	1	—
Cornell C	0	11	—	—	—	—	—
Cornell U	27	26	45	23	78	23	6
Creighton U	5	39	4	—	—	—	—
Dartmouth C	0	24	0	6	—	—	—
David Lipscomb C	0	15	—	—	—	—	—
Davidson C	9	4	—	—	—	—	—
Dayton, U of	11	3	1	—	32	5	—
Delaware State C	2	1	—	—	—	—	—
Delaware, U of	35	17	4	7	77	10	8
Delaware Valley C of Science & Agriculture	5	0	—	—	—	—	—
Delta State U	1	6	—	—	—	—	—
Denison U	3	5	—	—	—	—	—
Denver, U of	6	7	2	0	—	—	—
DePaul U	0	0	5	—	—	—	—
DePauw U	4	8	—	—	—	—	—
Detroit, U of	6	4	3	1	a	—	—
Dickinson C	4	10	—	—	—	—	—
Drake U	4	7	—	—	—	—	—
Drew U	1	7	—	—	—	—	—
Drexel U	14	0	9	4	75	4	1
Duke U	16	60	1	13	—	—	—
Duquesne U	0	2	11	3	—	—	—
Earlham C	3	7	—	—	—	—	—
East Carolina U	6	9	0	—	—	—	—
East Stroudsburg State U	7	15	0	—	—	—	—
East Tennessee State U	6	9	2	—	—	—	—
East Texas State U	3	2	10	—	—	—	—
Eastern Illinois U	6	3	6	—	—	—	—
Eastern Kentucky U	4	13	1	—	—	—	—
Eastern Michigan U	4	26	7	—	—	—	—
Elizabethtown C	0	13	—	—	—	—	—
Elmhurst C	3	15	—	—	—	—	—
Emory U	9	97	11	3	—	—	—
Emporia State U	5	3	2	—	—	—	—
Evansville, U of	3	3	—	—	—	—	—
Fairfield U	6	4	—	—	—	—	—
Fairleigh Dickinson U							
Madison	2	10	7	—	—	—	—
Rutherford	2	0	2	—	—	—	—
Teaneck	6	0	4	—	—	—	—
Fisk U	11	0	4	—	—	—	—
Florida Atlantic U	8	28	3	1	—	—	—
Florida Institute of Tech	1	0	0	—	—	—	—
Florida State U	12	22	4	11	—	—	—
Florida, U of	13	58	12	27	90	10	4
Fordham U	0	14	5	1	—	—	—
Fort Lewis C	2	6	—	—	—	—	—
Franklin & Marshall C	11	8	—	—	—	—	—
Furman U	18	0	3	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Geneva C	0	3	—	—	—	—	—
George Mason U	9	7	—	—	—	—	—
George Washington U	4	13	1	1	—	—	—
Georgetown U	19	0	11	6	—	—	—
Georgia Institute of Tech	20	0	7	5	155	20	1
Georgia State U	2	1	6	—	—	—	—
Georgia, U of	8	55	12	15	—	—	—
Gettysburg C	2	5	—	—	—	—	—
Glassboro State C	13	4	—	—	—	—	—
Gonzaga U	3	4	—	—	—	—	—
Goucher C	2	12	—	—	—	—	—
Grand Valley State C	0	9	—	—	—	—	—
Grinnell C	2	17	—	—	—	—	—
Gustavus Adolphus C	8	11	—	—	—	—	—
Hamilton C	0	10	—	—	—	—	—
Hamline U	7	1	—	—	—	—	—
Hampden-Sydney C	5	7	—	—	—	—	—
Hampton Institute	5	2	1	—	—	—	—
Hartford, U of	2	6	0	—	—	—	—
Hartwick C	4	1	—	—	—	—	—
Harvard U	0	26	9	27	—	—	—
Harvey Mudd C	13	0	—	—	—	—	—
Haverford C	3	11	—	—	—	—	—
Hawaii, U of	16	4	2	1	—	—	—
Hiram C	10	6	—	—	—	—	—
Hobart & William Smith C	2	12	—	—	—	—	—
Hofstra U	10	2	—	—	—	—	—
Hollins C	0	1	—	—	—	—	—
Holy Cross, C of the	29	16	—	—	—	—	—
Hope C	15	28	—	—	—	—	—
Houston, U of	19	2	7	13	47	47	9
Howard U	3	28	5	6	18	—	—
Humboldt State U	4	4	—	—	—	—	—
Idaho State U	5	2	0	—	—	—	—
Idaho, U of	6	6	2	6	13	14	0
Illinois Benedictine C	8	0	—	—	—	—	—
Illinois Institute of Tech	4	0	5	2	a	—	—
Illinois State U	41	1	3	—	—	—	—
Illinois, U of							
Chicago	13	22	26	5	65	9	0
Urbana-Champaign	51	62	18	66	125	24	13
Illinois Wesleyan U	0	5	—	—	—	—	—
Indiana State U	12	1	1	—	—	—	—
Indiana U							
Bloomington	28	92	12	29	—	—	—
South Bend	2	4	—	—	—	—	—
Indiana U of Pennsylvania	9	3	4	—	—	—	—
Indiana U-Purdue U							
Fort Wayne	2	3	—	—	—	—	—
Indianapolis	3	17	7	—	—	—	—
Iowa State U	12	1	5	22	58	6	4
Iowa, U of	8	2	5	4	19	7	1
Ithaca C	4	6	—	—	—	—	—
Jackson State U	6	3	0	—	—	—	—
James Madison U	1	16	—	—	—	—	—
John Carroll U	8	22	0	—	—	—	—
Johns Hopkins U	16	0	10	9	—	—	—
Juniata C	2	16	—	—	—	—	—
Kalamazoo C	5	17	—	—	—	—	—
Kansas State U	5	5	5	8	36	4	3
Kansas, U of	8	18	2	7	49	5	4
Kean C of New Jersey	2	16	—	—	—	—	—
Kearney State C	1	5	—	—	—	—	—
Kent State U	7	13	1	8	—	—	—
Kentucky, U of	4	13	7	6	51	5	2
Kenyon C	12	5	—	—	—	—	—
King's C	3	4	—	—	—	—	—
Knox C	4	22	—	—	—	—	—
Lafayette C	11	9	—	—	37	—	—
Lake Forest C	1	8	—	—	—	—	—
Lamar U	6	1	2	—	32	4	0
LaSalle C	10	6	—	—	—	—	—
Lawrence Institute of Tech	11	0	—	—	—	—	—
Lawrence U[c]	3	8	11	2	—	—	—
Lebanon Valley C	4	1	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Lehigh U	19	0	4	8	85	25	3
LeMoyne C	4	0	—	—	—	—	—
Lincoln U	0	8	—	—	—	—	—
Long Island U							
Brooklyn Center	3	3	5	—	—	—	—
C. W. Post C	8	4	—	—	—	—	—
Loras C	3	5	—	—	—	—	—
Louisiana State U							
Baton Rouge	6	3	2	11	81	6	6
Shreveport	4	0	—	—	—	—	—
Louisiana Tech U	0	3	4	—	28	3	1
Louisville, U of	7	19	1	1	28	18	0
Lowell, U of	9	2	3	3	47	3	—
Loyola C	5	1	—	—	—	—	—
Loyola M[illegible]ount U	4	1	—	—	—	—	—
Loyola U [illegible]w Orleans	3	1	—	—	—	—	—
Loyola U [illegible] Chicago	11	14	2	2	—	—	—
Luther C	0	9	—	—	—	—	—
Macalester C	3	9	—	—	—	—	—
MacMurray C	0	2	—	—	—	—	—
Maine, U of	6	1	6	2	31	6	0
Manhattan C[d]	4	1	—	—	56	23	—
Manhattanville C	2	0	—	—	—	—	—
Mankato State U	7	9	0	—	—	—	—
Marietta C	2	1	—	—	—	—	—
Marist C	0	4	—	—	—	—	—
Marquette U	12	3	5	3	—	—	—
Marshall U	5	19	3	—	—	—	—
Maryland, U of							
Baltimore County	6	16	0	0	—	—	—
College Park	19	70	10	21	68	11	0
Massachusetts Institute of Tech	39	0	3	41	96	66	13
Massachusetts, U of	16	3	10	22	60	7	4
McMurry C	1	5	—	—	—	—	—
McNeese State U	4	3	1	—	—	—	—
Memphis State U	2	7	3	0	—	—	—
Mercer U	10	3	—	—	—	—	—
Merrimack C	11	0	—	—	—	—	—
Metropolitan State C	14	18	—	—	—	—	—
Miami U	30	37	3	6	—	—	—
Miami, U of	5	91	1	0	—	—	—
Michigan State U	27	15	13	33	76	11	4
Michigan Tech U	14	0	2	2	97	9	0
Michigan, U of							
Ann Arbor	75	0	20	17	124	38	6
Dearborn	10	11	—	—	—	—	—
Flint	2	7	—	—	—	—	—
Middle Tennessee State U	2	18	6	—	—	—	—
Middlebury C	1	7	0	—	—	—	—
Midwestern State U	2	6	—	—	—	—	—
Millersville U of Pennsylvania	5	4	—	—	—	—	—
Millsaps C	2	14	—	—	—	—	—
Minnesota, U of							
Duluth	14	9	6	—	—	—	—
Minneapolis	23	0	7	12	169	19	16
Mississippi C	0	11	—	—	—	—	—
Mississippi State U	2	2	0	0	65	4	0
Mississippi, U of	1	27	2	6	25	0	1
Missouri, U of							
Columbia	6	8	11	4	55	3	1
Kansas City	7	11	0	2	—	—	—
Rolla	9	0	6	3	74	18	4
St. Louis	11	12	4	0	—	—	—
Missouri Western State C	0	5	—	—	—	—	—
Monmouth C	1	6	—	—	—	—	—
Montana C of Mineral Science & Tech	1	1	3	—	—	—	—
Montana State U	6	9	3	11	60	9	2
Montana, U of	7	5	4	1	—	—	—
Montclair State C	2	18	6	—	—	—	—
Moorhead State U	3	4	—	—	—	—	—
Moravian C	3	3	—	—	—	—	—
Morehouse C[e]	3	0	6	1	—	—	—
Morgan State U	3	6	—	—	—	—	—
Mount Holyoke C	0	19	2	0	—	—	—
Mount Saint Vincent, C of[d]	1	2	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Muhlenberg C	3	17	—	—	—	—	—
Murray State U	5	14	6	—	—	—	—
Muskingum C	3	5	—	—	—	—	—
Nebraska, U of							
Lincoln	9	6	6	23	a	—	—
Omaha	8	3	—	—	—	—	—
Nebraska Wesleyan U	2	1	—	—	—	—	—
Nevada, U of							
Las Vegas	2	4	—	—	—	—	—
Reno	1	6	0	3	—	—	—
New Hampshire, U of	5	7	4	5	31	4	1
New Jersey Institute of Tech[b]	—	—	—	—	98	21	4
New Mexico Highlands U	0	2	1	—	—	—	—
New Mexico Institute of Tech	6	0	4	—	—	—	—
New Mexico State U	6	10	3	7	38	5	—
New Mexico, U of	11	7	6	8	35	8	4
New Orleans, U of	2	15	3	5	—	—	—
New York U	9	30	16	14	—	—	—
Niagara U	1	9	—	—	—	—	—
North Alabama, U of	3	12	—	—	—	—	—
North Carolina A&T State U	5	0	5	—	—	—	—
North Carolina Central U	0	3	2	—	—	—	—
North Carolina State U	14	9	5	9	108	10	2
North Carolina, U of							
Asheville	3	2	—	—	—	—	—
Chapel Hill	40	96	8	32	—	—	—
Charlotte	6	4	2	—	—	—	—
Greensboro	10	6	3	—	—	—	—
Wilmington	0	14	—	—	—	—	—
North Dakota State U	1	12	3	4	24	4	—
North Dakota, U of	0	2	1	1	—	—	—
North Texas State U	5	10	10	5	—	—	—
Northeast Louisiana U	4	0	2	—	—	—	—
Northeastern U	5	0	9	4	36	16	0
Northern Arizona U	9	37	0	—	—	—	—
Northern Colorado, U of	0	7	2	1	—	—	—
Northern Illinois U	10	11	9	8	—	—	—
Northern Iowa, U of	6	15	0	—	—	—	—
Northern Kentucky U	1	6	—	—	—	—	—
Northern Michigan U	2	14	1	—	—	—	—
Northwest Missouri State U	5	1	—	—	—	—	—
Northwestern State U of Louisiana	0	4	—	—	—	—	—
Northwestern U	20	14	26	19	51	18	7
Norwich U	0	0	—	—	—	—	—
Notre Dame, U of	8	16	8	11	76	9	2
Oakland U	9	5	0	—	—	—	—
Oberlin C	1	22	—	—	—	—	—
Occidental C	3	17	—	—	—	—	—
Ohio Northern U	3	10	—	—	—	—	—
Ohio State U	27	0	11	27	83	12	6
Ohio U	13	5	3	5	20	11	0
Ohio Wesleyan U	3	14	—	—	—	—	—
Oklahoma State U	4	5	3	7	62	20	10
Oklahoma, U of	12	17	5	3	63	11	1
Old Dominion U	3	4	7	—	—	—	—
Oregon State U	8	0	5	5	45	16	1
Oregon, U of	7	32	3	7	—	—	—
Pace U	0	5	—	—	—	—	—
Pacific Lutheran U	4	6	—	—	—	—	—
Pacific, U of the	2	11	2	1	—	—	—
Pennsylvania State U	2	5	6	23	216	23	2
Pennsylvania, U of	8	28	4	17	55	9	7
Philadelphia C of Pharmacy & Science	4	0	0	0	—	—	—
Philadelphia C of Textiles & Science	5	0	—	—	—	—	—
Pittsburg State U	7	2	0	—	—	—	—
Pittsburgh, U of	19	76	15	13	105	30	7
Polytechnic Institute of New York	10	1	5	9	38	24	3
Pomona C	8	3	—	—	—	—	—
Portland State U	1	10	3	4	—	—	—
Pratt Institute[b]	—	—	—	—	9	—	—
Princeton U	11	9	33	14	51	2	11
Providence U	7	1	0	0	—	—	—
Puerto Rico, U of							
Mayaguez	13	11	2	—	61	2	0
Rio Piedras	25	34	2	2	—	—	—
Puget Sound, U of	5	0	—	—	—	—	—
Purdue U	29	21	9	34	146	18	6
Purdue U Calumet	1	2	—	—	—	—	—
Randolph-Macon Woman's C	2	5	—	—	—	—	—
Redlands, U of	0	1	—	—	—	—	—
Reed C	15	2	—	—	—	—	—
Regis C	1	5	—	—	—	—	—
Rensselaer Polytechnic Institute	34	0	11	6	104	14	4
Rhode Island, U of	6	2	2	5	26	4	0
Rice U	12	2	1	15	37	11	3
Richmond, U of	1	15	1	—	—	—	—
Rider C	4	0	—	—	—	—	—
Ripon C	2	4	—	—	—	—	—
Roanoke C	1	4	—	—	—	—	—
Rochester Institute of Tech	9	4	3	—	—	—	—
Rochester, U of	8	6	26	14	57	15	4
Rollins C	4	0	—	—	—	—	—
Roosevelt U	8	1	4	—	—	—	—
Rose-Hulman Institute of Tech	11	0	—	—	53	2	—
Russell Sage C	3	2	—	—	—	—	—
Rutgers U							
Camden C	8	7	—	—	—	—	—
New Brunswick	46	12	7	10	108	19	2
Newark C of Arts & Sciences	10	13	7	9	—	—	—
Saginaw Valley State C	2	9	—	—	—	—	—
St. Anselm C	1	4	—	—	—	—	—
St. Cloud State U	1	4	—	—	—	—	—
St. John Fisher C	12	0	—	—	—	—	—
St. John's U	8	3	3	—	—	—	—
St. Joseph C	2	1	1	—	—	—	—
St. Joseph's U	8	13	6	—	—	—	—
St. Lawrence U	11	19	—	—	—	—	—
St. Louis U	9	36	5	—	—	—	—
St. Mary's C	5	9	—	—	—	—	—
St. Michael's C	0	4	—	—	—	—	—
St. Olaf C	6	31	—	—	—	—	—
St. Peter's C	0	3	—	—	—	—	—
St. Thomas, C of	2	4	—	—	—	—	—
Salem State C	4	0	—	—	—	—	—
Sam Houston State U	11	0	4	—	—	—	—
San Diego State U	17	3	8	1	—	—	—
San Francisco State U	6	28	7	—	—	—	—
San Francisco, U of	5	5	5	—	—	—	—
San Jose State U	20	14	11	—	17	10	—
Santa Clara, U of	3	4	—	—	—	—	—
Scranton, U of	8	11	21	—	—	—	—
Seattle U	2	6	—	—	—	—	—
Seton Hall U	8	1	13	8	—	—	—
Shippensburg U	11	8	4	—	—	—	—
Siena C	12	0	—	—	—	—	—
Simmons C	8	1	—	—	—	—	—
Skidmore C	3	21	—	—	—	—	—
Slippery Rock State C	0	3	—	—	—	—	—
Smith C	2	4	0	0	—	—	—
Sonoma State U	0	13	—	—	—	—	—
South Carolina, U of	7	21	5	13	35	6	2
South Dakota School of Mines & Tech	12	2	5	—	29	5	—
South Dakota State U	0	28	3	—	—	—	—
South Dakota, U of	3	15	2	—	—	—	—
South Florida, U of	16	58	1	0	35	3	0
Southeast Missouri State U	0	6	—	—	—	—	—
Southeastern Louisiana U[f]	—	—	—	—	—	—	—
Southeastern Massachusetts U	6	2	1	—	—	—	—
Southern California, U of	17	7	2	20	32	11	0
Southern Colorado, U of[f]	—	—	—	—	—	—	—
Southern Illinois U							
Carbondale	1	17	2	6	—	—	—
Edwardsville	11	7	4	—	—	—	—
Southern Methodist U	7	18	2	—	—	—	—
Southern Mississippi, U of	2	17	4	3	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Southern Oregon State C	0	4	—	—	—	—	—
Southern U & A&M C	6	0	1	—	—	—	—
Southwest Missouri State U	1	12	—	—	—	—	—
Southwest State U	1	8	—	—	—	—	—
Southwest Texas State U	20	3	4	—	—	—	—
Southwestern at Memphis	3	4	—	—	—	—	—
Southwestern Louisiana, U of	1	8	1	—	11	7	—
Southwestern Oklahoma State U	4	7	—	—	—	—	—
Stanford U	9	12	2	17	19	22	8
State U of New York							
Albany	25	3	3	2	—	—	—
Binghamton	4	36	1	5	—	—	—
Buffalo	9	13	6	12	78	9	3
Stony Brook	14	43	6	15	—	—	—
C at Brockport	5	1	—	—	—	—	—
C at Buffalo	6	6	2	—	—	—	—
C at Cortland	2	5	—	—	—	—	—
C at Fredonia	11	14	2	—	—	—	—
C at Geneseo	6	0	0	—	—	—	—
C at New Paltz	13	1	1	—	—	—	—
C at Oneonta	2	19	0	—	—	—	—
C at Oswego	12	0	0	—	—	—	—
C at Plattsburgh	6	14	0	—	—	—	—
C at Potsdam	3	19	—	—	—	—	—
Stephen F. Austin State U	5	12	2	—	—	—	—
Stetson U	2	3	—	—	—	—	—
Stevens Institute of Tech	8	0	14	3	—	—	—
Suffolk U	3	5	—	—	—	—	—
Susquehanna U	1	5	—	—	—	—	—
Swarthmore C	6	8	—	—	—	—	—
Syracuse U	23	7	4	4	22	5	0
Temple U	8	6	7	4	—	—	—
Tennessee Technological U	4	10	3	—	47	9	—
Tennessee, U of							
Chattanooga	10	19	—	—	—	—	—
Knoxville	5	13	4	8	73	11	5
Martin	5	5	—	—	—	—	—
Texas A&I U	2	0	2	—	21	9	—
Texas A&M U	30	13	4	29	158	10	1
Texas Christian U	1	10	2	4	—	—	—
Texas Southern U	21	0	7	—	—	—	—
Texas Tech U	16	9	4	4	41	9	1
Texas, U of							
Arlington	12	9	7	0	—	—	—
Austin	57	0	3	24	101	39	6
Dallas	6	2	0	—	—	—	—
El Paso	14	1	9	—	—	—	—
Texas Woman's U	2	4	0	2	—	—	—
Thiel C	1	5	—	—	—	—	—
Thomas More C	6	0	—	—	—	—	—
Toledo, U of	3	20	3	1	20	6	1
Towson State U	2	5	—	—	—	—	—
Trenton State C	11	0	—	—	—	—	—
Trinity C	9	9	0	—	—	—	—
Trinity U	0	4	0	—	—	—	—
Tri-State U[b]	—	—	—	—	a	—	—
Tufts U	0	26	4	0	37	4	1
Tulane U of Louisiana	2	10	1	2	28	5	0
Tulsa, U of	1	0	—	—	a	—	—
Tuskegee Institute	0	4	1	—	—	—	—
Union C	6	12	0	—	—	—	—
U.S. Air Force Academy	6	4	—	—	—	—	—
U.S. Naval Academy	17	0	—	—	—	—	—
Ursinus C	9	16	—	—	—	—	—
Utah State U	5	0	0	8	—	—	—
Utah, U of	4	25	3	9	a	—	—
Valparaiso U	4	38	—	—	—	—	—
Vanderbilt U	3	22	2	9	31	4	1
Vassar C	2	2	0	—	—	—	—
Vermont, U of	27	0	5	3	—	—	—
Villanova U	9	0	14	7	38	6	—
Virginia Commonwealth U	14	38	3	2	—	—	—
Virginia Military Institute	13	0	—	—	—	—	—
Virginia Polytechnic Institute & State U	14	14	10	6	79	5	3
Virginia, U of	3	69	4	4	49	28	3
Wabash C	7	11	—	—	—	—	—
Wagner C	0	7	—	—	—	—	—
Wake Forest U	3	9	0	0	—	—	—
Washburn U of Topeka	1	2	—	—	—	—	—
Washington C	2	0	—	—	—	—	—
Washington and Jefferson C	2	27	—	—	—	—	—
Washington and Lee U	1	6	—	—	—	—	—
Washington State U	8	8	11	8	21	6	0
Washington U	9	7	4	3	40	3	6
Washington, U of	59	18	17	14	58	6	7
Wayne State U	20	23	7	9	50	19	5
Waynesburg C	0	0	—	—	—	—	—
Weber State C	3	7	—	—	—	—	—
Wellesley C	1	18	—	—	—	—	—
Wesleyan U	4	15	0	7	—	—	—
West Chester U	5	14	2	—	—	—	—
West Florida, U of	16	2	—	—	—	—	—
West Texas State U	0	13	2	—	—	—	—
West Virginia Institute of Tech	3	0	—	—	25	0	—
West Virginia State C	2	4	—	—	—	—	—
West Virginia U	9	38	1	3	43	9	0
Western Illinois U	4	5	1	—	—	—	—
Western Kentucky U	5	8	4	—	—	—	—
Western Maryland C	3	11	—	—	—	—	—
Western Michigan U	4	20	0	4	—	—	—
Western New England C	2	2	—	—	—	—	—
Western Washington U	13	12	6	—	—	—	—
Westminster C	0	8	—	—	—	—	—
Wheaton C (Illinois)	5	15	—	—	—	—	—
Wheaton C (Massachusetts)	1	6	—	—	—	—	—
Wheeling C	0	1	—	—	—	—	—
Whitman C	3	5	—	—	—	—	—
Whittier C	3	3	—	—	—	—	—
Wichita State U	9	3	6	0	—	—	—
Widener U	3	0	—	—	—	—	—
Wilkes C	7	4	—	—	—	—	—
Willamette U	2	7	—	—	—	—	—
William Paterson C of New Jersey	0	6	—	—	—	—	—
William and Mary, C of	32	2	2	—	—	—	—
Williams C	4	17	—	—	—	—	—
Wisconsin, U of							
Eau Claire	3	10	—	—	—	—	—
Green Bay	0	10	—	—	—	—	—
La Crosse	2	11	—	—	—	—	—
Madison	12	14	4	37	120	13	11
Milwaukee	2	13	3	2	—	—	—
Oshkosh	10	3	0	—	—	—	—
Parkside	1	6	—	—	—	—	—
Platteville	0	2	—	—	—	—	—
River Falls	11	6	—	—	—	—	—
Stevens Point	9	7	—	—	—	—	—
Superior	0	3	—	—	—	—	—
Wittenberg U	2	6	—	—	—	—	—
Wooster, C of	5	25	—	—	—	—	—
Worcester Polytechnic Institute	3	6	2	2	48	7	2
Wright State U	16	20	14	—	—	—	—
Wyoming, U of	1	5	6	4	18	6	0
Xavier U	9	9	2	—	—	—	—
Xavier U of Louisiana	1	17	—	—	—	—	—
Yale U	10	0	26	26	—	—	—
Youngstown State U	6	50	5	—	23	—	—
TOTALS	**4233**	**5810**	**1569**	**1759**	**7021**	**1317**	**333**

a Data not submitted. **b** Listed on basis of accreditation by AIChE-ABET. **c** Master's and Ph.D. degrees given by the Institute of Paper Chemistry. **d** The chemistry programs at Mount Saint Vincent and Manhattan College are integrated into a combined department with all instruction in chemistry located at Manhattan College. **e** Master's degrees given by Atlanta University. **f** Added in 1983. **Note:** For brevity, "B.S." and "M.S." are used to denote all bachelor's and master's degrees, respectively, in each column.

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MAY 14, 1984

CHEMICAL & ENGINEERING

NEWS

rst-quarter earnings:
pward march continues
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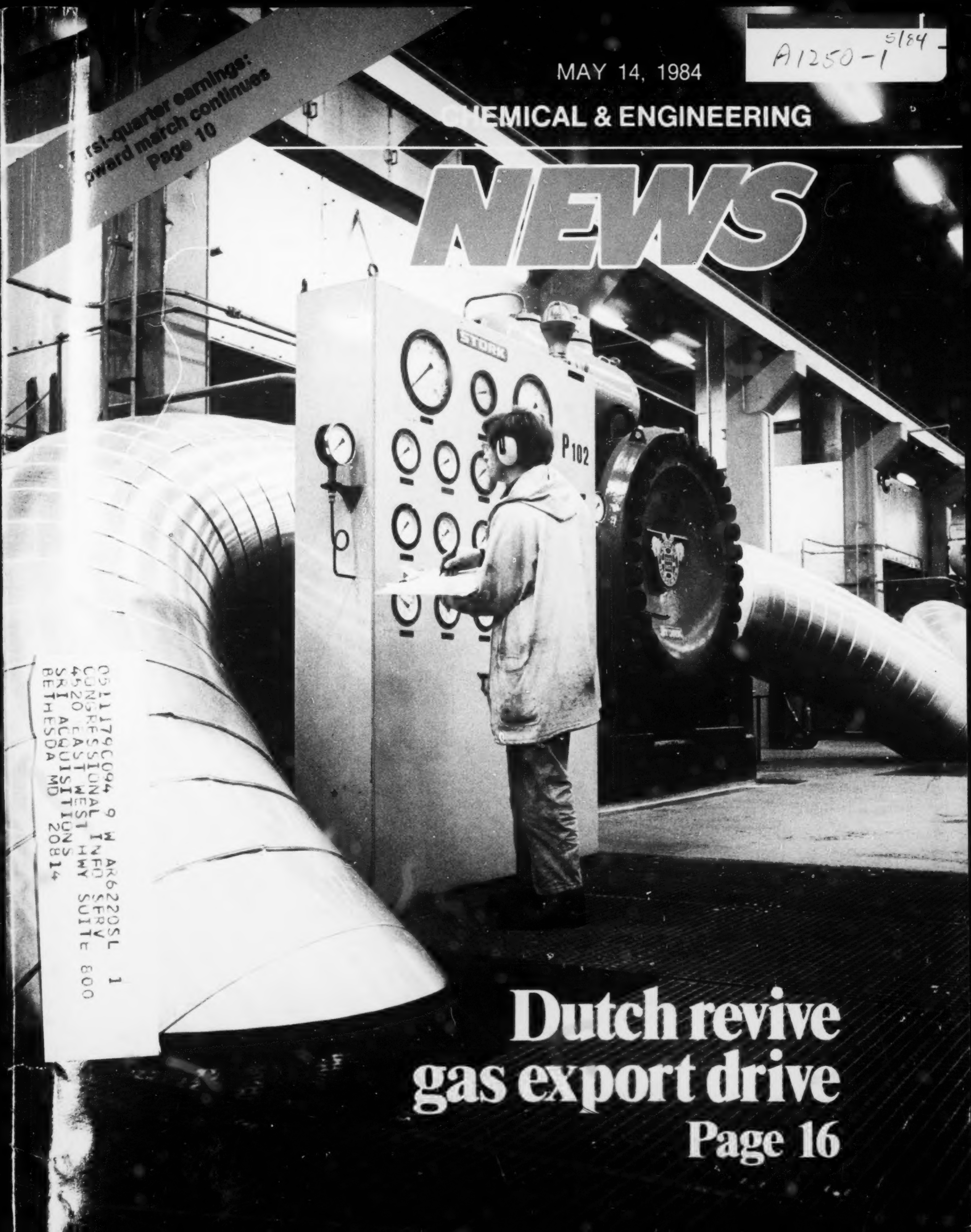

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Dutch revive gas export drive

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Cover: Gasunie engineer checks readings in world's largest natural gas compressor station at Ommen, the Netherlands

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CHEMICAL & ENGINEERING NEWS

MAY 14, 1984

News of the Week

- **Chemical firms that supplied agent orange to the government agree to pay $180 million to settle lawsuit but admit no liability. Page 6**
- **EPA spells out penalties for violators of hazardous waste rules under RCRA. Page 7**
- **U.S. aerosol industry increased output 8.9% in 1983 over the previous year. Page 7**
- **Biotechnology firms face another issue: those who oppose genetic research on safety grounds. Page 8**
- **Ciba-Geigy continues to beef up its U.S. pigments business. Page 8**

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Business

Increases in chemical earnings continued through the first three months of 1984 as sales rose along with productivity. **Page 10**

Olin Corp.'s employee involvement teams, measuring system have boosted productivity and profits even in the recession. **Page 14**

Government

Synthetic Fuels Corp. is in trouble: the resignation of its president leaves board without a quorum, Congress is critical. **Page 20**

Commerce Department report on costs of cleaning hazardous waste sites under Superfund law raises ire on Capitol Hill. **Page 22**

Science

Study of resonances—metastable species held together by atomic interactions—aids understanding of chemical reactions. **Page 26**

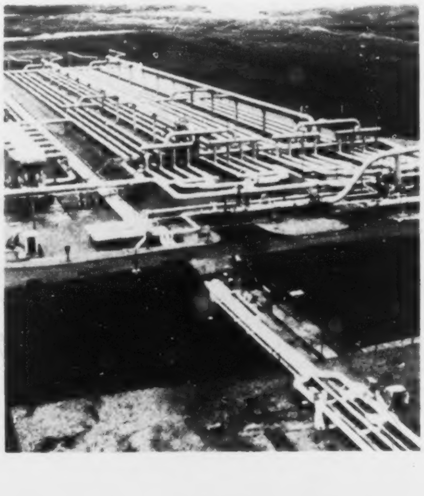
Education

Lehigh's interdepartmental institutes and strong community ties make it likely leader in upgrading local industry. **Page 37**

Technology

Chitin, a waste problem for seafood processors, may have many uses in medicine, agriculture, and animal feeds. **Page 42**

Research in liquid crystals shows promise for their use in high-strength fibers, to generate stable colors without dyes. **Page 46**



International Business

Netherlands' Gasunie is resuming exports of natural gas but faces increasing competition. Page 16

Chemical Industry Earnings Retain Vigor in First Quarter

Basic chemical firms record big gain over first-quarter 1983; chemical segments are bright spot for energy firms and diversified manufacturers

David Webber, C&EN New York

The chemical industry earnings recovery more than retained its vigor in the first quarter of 1984. Swelling sales volumes combined with the operating efficiencies that were solidified last year to infuse health to the bottom line of the industry's income statements. The only important twinge left over from the recession was pricing, which improved only grudgingly in the first quarter.

The result was big increases in earnings all around. For 30 basic chemical producers, net income rose 70% on a sales revenue increase of 13% in the first quarter, according to C&EN's latest survey of major companies.

A group of 26 diversified manufacturers with significant chemical operations recorded an overall earnings jump of 77% on a revenue increase of 11%. And 16 oil and gas firms reported a 33% boost in income on a 4% rise in sales.

The rosy numbers, coming after the near-doubling of earnings in fourth-quarter 1983, prompted a round of dividend increases and stock splits at a number of companies. Earnings per share values rose sharply as well, although some of the increases were due to companies' repurchasing and retiring substantial amounts of stock in some cases.

In general, plastics and agricultural chemicals led the recovery among chemical producers. The sharpest improvement was registered by Celanese, which moved from 24th to eighth on the list of earnings leaders for the quarter with a 633% rise in net income. Celanese chief executive John D. Macomber attributes the gain to fibers, engineering resins, and lower breakeven points. Hercules, which reported a 35% increase in net income, said most of its gain was generated by its polypropylene resins and fibers businesses.

At Monsanto, where overall earnings rose 73%, polymer products operating income ballooned 155%. National Distillers & Chemical, with a 91% profit rise, benefited primarily from the polyethylene and other operations of its U.S.I. subsidiary, chief executive Drummond C. Bell says.

Despite the cold and wet weather of the first quarter, most producers of agricultural chemicals did well compared to their performance in last year's market, which was hurt by the government's payment-in-kind (PIK) program. In earnings statements, such chief executives as Edward Donley of Air Products & Chemicals and J. Peter Grace of W. R. Grace cite the turnaround in agricultural chemicals as a prime factor in the rise in earnings. At International Minerals & Chemicals, where fertilizer is the principal business line, earnings rose 26%. Modest fertilizer price increases helped, notes IMC president George D. Kennedy, though he says further increases are needed to achieve a satisfactory return on investment.

At Monsanto, agricultural and nutritional products operating earnings rose 34%. "Our agricultural

Chemical industry leaders for the first quarter

Sales			Earnings[a]			Profitability		
Rank	$ Millions	Rank 1983		$ Millions	Rank 1983		Earnings as % of sales	Rank 1983
1 Dow Chemical	$2916.0	1	Monsanto	$175.0	1	International Flavors	15.2%	1
2 Union Carbide	2393.0	2	Dow Chemical	122.0	2	Freeport McMoRan	10.9	2
3 Monsanto	1732.0	3	Union Carbide	107.0	4	Loctite	10.5	6
4 W. R. Grace	1497.3	4	PPG Industries	74.1	3	Nalco Chemical	10.4	3
5 PPG Industries	1035.8	5	American Cyanamid	56.5	11	Rohm & Haas	10.3	7
6 American Cyanamid	938.6	6	Rohm & Haas	56.3	5	Monsanto	10.1	8
7 Celanese	837.0	7	Hercules	47.0	8	Petrolite	8.2	5
8 National Distillers	747.2	9	Celanese	44.0	24	Air Products	8.1	9
9 Hercules	619.0	8	Air Products	36.6	7	Lubrizol	8.0	4
10 Rohm & Haas	548.1	11	W. R. Grace	31.9	6	Hercules	7.6	16

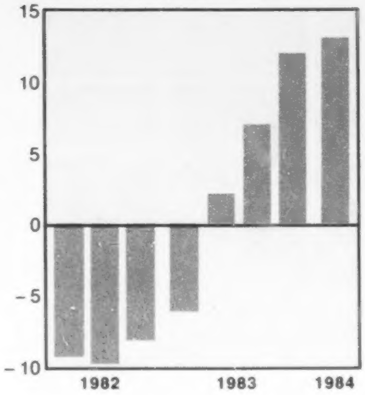
a After taxes. **Note:** For 30 companies listed on page 12.

Chemical industry 1984 first-quarter results

- Sales increased 13%
- Earnings shot up 70%
- Profit margins hit 5.7%
- Production climbed 11%
- Prices rose nearly 3%

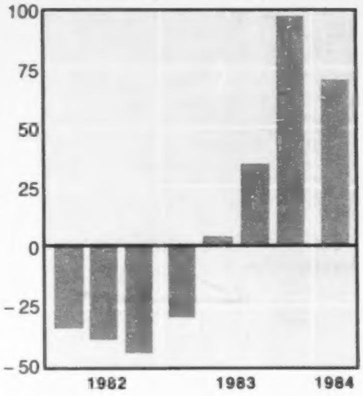
Sales

% change from year-earlier quarter



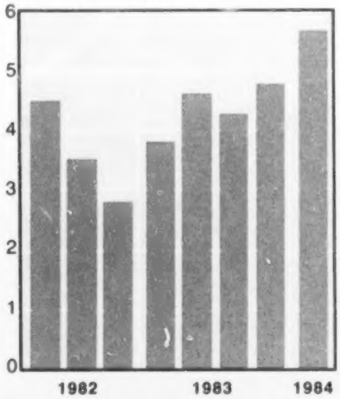
Earnings

% change from year-earlier quarter



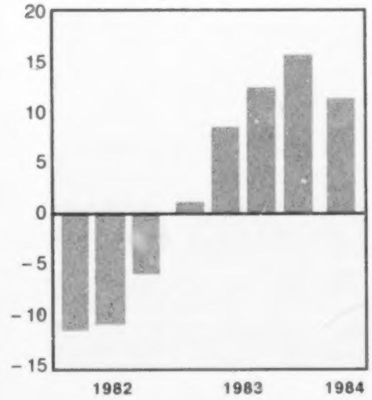
Profit margins

After-tax earnings as % of sales



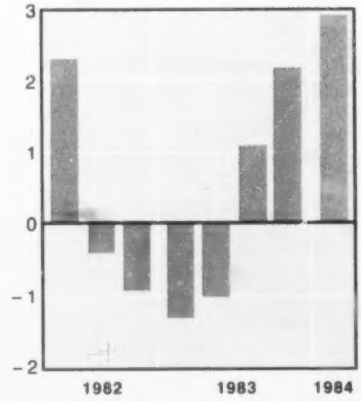
Production

% change from year-earlier quarter



Prices

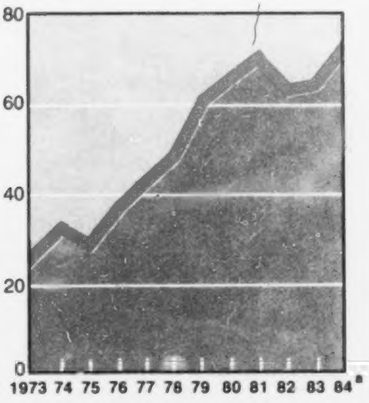
% change from year-earlier quarter



Sales in 1984 will rise 12% and earnings will increase 35%, moving chemical profitability up sharply

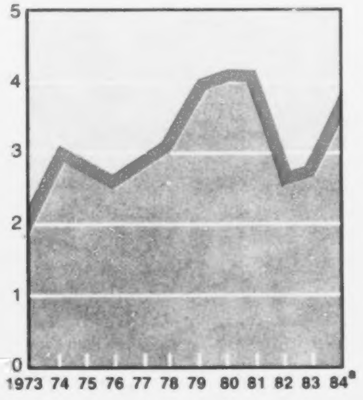
Annual sales

$ Billions



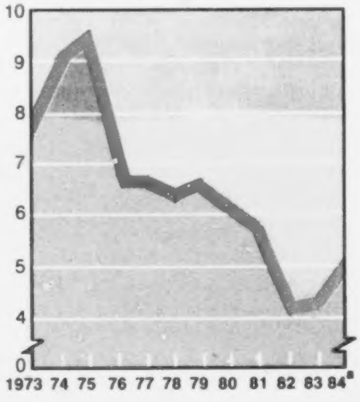
Annual earnings

$ Billions



Annual profit margins

After-tax earnings as % of sales



a C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined results of the 30 leading chemical companies listed on page 12.

Chemical company earnings rose sharply in first quarter

	FIRST-QUARTER 1984						12-MONTH RUNNING DATA			
	Sales	Earnings[a]	Change from 1983		Profit margin[b]		Change from 1983		Profit margin[b]	
	($ millions)		Sales	Earnings	1984	1983	Sales	Earnings	1984	1983
Air Products	$ 452.1	$ 36.6	7%	38%	8.1%	6.3%	6%	31%	7.5%	6.0%
American Cyanamid	938.6	56.5	14	108	6.0	3.3	6	57	5.4	3.6
Celanese	837.0	44.0	9	633	5.3	0.8	12	def	4.5	def
Chemed[c]	81.4	5.0	34	34	6.1	6.1	17	22	6.4	6.1
Crompton & Knowles	60.0	1.8	10	45	3.0	2.3	11	57	2.9	2.0
Dow Chemical	2,916.0	122.0	13	126	4.2	2.1	9	115	3.4	1.7
Essex Chemical	44.1	1.9	7	4	4.3	4.5	10	−56	1.7	4.4
Ethyl	418.1	24.7	6	22	5.9	5.1	10	19	6.6	6.0
First Mississippi	72.1	4.8	53	187	6.6	3.5	23	−14	4.8	6.9
Freeport-McMoRan	202.7	22.1	−1	5	10.9	10.3	4	1	11.8	12.2
H. B. Fuller	104.8	1.6	13	−16	1.5	2.0	23	45	3.1	2.7
W. R. Grace	1,497.3	31.9	11	177	2.1	0.8	3	6	2.8	2.7
Hercules	619.0	47.0	14	35	7.6	6.4	5	−17	3.2	4.0
International Flavors	123.5	18.7	2	2	15.2	15.1	6	58	6.8	4.5
International Minerals	388.8	26.8	5	26	6.9	5.7	4	1	10.6	10.9
Loctite	62.6	6.6	13	38	10.5	8.6	4	26	5.9	4.9
Lubrizol	212.3	16.9	14	51	8.0	6.0	12	59	8.9	6.3
Monsanto	1,732.0	175.0	17	73	10.1	6.8	12	68	9.5	6.4
Morton Thiokol	541.3	28.7	21	23	5.3	5.3	6	43	6.0	4.4
Nalco Chemical	175.6	18.3	10	11	10.4	10.3	58	82	7.2	6.2
National Distillers	747.2	28.6	27	91	3.8	2.6	16	28	6.5	6.0
Olin	526.5	27.2	11	20	5.2	4.8	37	4	3.2	4.2
PPG Industries	1,035.8	74.1	21	69	7.2	5.1	15	46	4.9	3.9
Pennwalt	257.4	9.5	8	50	3.7	2.7	6	95	4.8	2.6
Petrolite	72.7	6.0	1	−6	8.2	8.8	−1	−20	7.5	9.3
Reichhold Chemicals	209.3	5.5	17	32	2.6	2.3	11	52	6.8	5.0
Rohm & Haas	548.1	56.3	19	67	10.3	7.3	5	88	6.6	3.7
Stauffer Chemical	418.8	16.0	15	−5	3.8	4.6	7	63	6.8	4.4
Union Carbide	2,393.0	107.0	9	157	4.5	1.9	6	12	2.6	2.4
Witco Chemical	366.7	14.7	14	38	4.0	3.3	10	56	3.9	2.8
Total 15 largest firms	**$15,620.8**	**$ 875.5**	**14%**	**83%**	**5.6%**	**3.5%**	**9%**	**48%**	**4.4%**	**3.3%**
Total second 15 firms	**$ 2,434.0**	**$ 160.1**	**10%**	**22%**	**6.6%**	**5.9%**	**9%**	**34%**	**7.0%**	**5.7%**
GRAND TOTAL	**$18,054.8**	**$1035.6**	**13%**	**70%**	**5.7%**	**3.8%**	**9%**	**44%**	**4.9%**	**3.7%**

a Excludes all significant extraordinary and nonrecurring items. **b** After-tax income as a percentage of sales. **c** Includes National Sanitary Supply, Fabrilife Chemicals, and Twirl Corp., all acquired in fourth-quarter 1983. No pro forma comparison.

products business improved from an acceleration of growth in worldwide sales of Roundup herbicide and from increased sales of Lasso herbicide and associated product mixes," chief executive Richard J. Mahoney says. Agricultural products accounted for 54% of the company's operating income in the first quarter.

Energy firms benefited greatly from chemicals

	First-quarter earnings on chemical operations[a]		
$ Millions	**1984**	**1983**	**% change**
Exxon	$121	$32	278.1%
Gulf	49	−39	nm
InterNorth	5	0	nm
Mobil	8	−14	nm
Shell	21	19	10.5
Standard Oil (Ind.)	59	18	227.8

a After-tax earnings. **nm** = not meaningful.

Other companies reporting strong gains stemming from the agricultural market were Pennwalt and Rohm & Haas, which note that increasing sales volumes were led by shipments of its major herbicides. But agricultural chemicals were not assurance of success. Stauffer Chemical recorded one of the few earnings declines in the first quarter, a 5% drop, because of slower than expected recovery by the corn herbicide market. The nation's cornbelt was the area most affected by the early spring's inclement weather.

There was plenty of strength in specialty chemicals operations, although not on the same scale as that of overall chemical performance. Morton Thiokol, for instance, which registered a 23% earnings increase overall, says operating earnings of its specialty chemicals segment jumped 47% on the strength of sales of electronic chemicals, sodium borohydride, and biocides. Net income was up 51% at Lubrizol and 38% at Loctite.

Signs of the spreading recovery could be seen in the improvement of Air Products' industrial gases operation, which had been held back by the sluggishness of the steel industry. And Union Carbide, which had been lagging the rest of the major chemical firms, recorded a 157% increase in net income in the quarter. "We feel good about this quarter," says chief executive Warren M. Anderson. "The current results put us firmly back on the earnings recovery track."

Problems in certain areas remain, on the other hand. American Cyanamid, for instance, registered a 106% profit rise overall, but thanks mostly to pharmaceuticals; the company's chemical group suffered because of lower earnings from oil-field chemicals. And Monsanto, despite its overall gains, notes that the laggardliness of capital goods markets continued to hold back its Fisher Controls unit, which reported a 13% decline in operating profit.

The diversified firms with chemical operations did even better than basic chemical producers. Among the bigger improvements, net income was up 375% at Uniroyal and 84% at Du Pont, which alone accounted for some 15% of the group's aggregate earnings in the quarter. At many firms, the chemical segment was one of the brightest spots, if not the brightest, on the corporate roster.

At Beatrice Foods, chemical operating earnings rose 32%, but corporate income declined 3%. At Du Pont, operating profit rose 206% for industrial and consumer products, 82% for fibers, 154% for polymer products, and 39% for agricultural and industrial chemicals. At B. F. Goodrich, which recorded an overall deficit in first-quarter 1983, polyvinyl chloride operations rose from a $19 million loss to a $7 million profit. Specialty chemicals' net increased 88%. NL Industries, which managed a minimal profit, reported chemical operating income up 31%. And Uniroyal saw operating profit of its chemical, rubber, and plastic materials segment shoot up 175% for the quarter.

For the energy companies, chemicals provided very welcome additions to income. Exxon's after-tax chemical earnings soared 278%; Standard Oil (Ind.)'s, 228%; and Shell Oil's, 11%. At the same time, after-tax chemical segment profit moved from a $39 million deficit in first-quarter 1983 to a $49 million net this period for Gulf; from a $14 million loss to an $8 million gain for Mobil; and from no profit to $5 million in income for InterNorth. ☐

Energy earnings up a third, diversified profits soar

	% chemical sales	Sales	Earnings[a]	Change from 1983		Profit margin[b]	
		($ millions)		Sales	Earnings	1984	1983
OIL AND GAS COMPANIES							
American Petrofina	15%	$ 547.9	$ 10.3	29%	2964%	1.9%	0.1%
Atlantic Richfield	10	6,742.4	395.1	7	20	5.9	5.2
Exxon	7	24,906.0	1475.0	5	39	5.9	4.5
Gulf	6	7,475.0	220.0	8	21	2.9	2.6
InterNorth[c]	7	1,999.8	133.5	47	31	6.7	7.5
Mobil	4	15,000.0	380.0	5	52	2.5	1.7
Occidental Petroleum	10	3,900.0	92.7	−20	836	2.4	0.2
Phillips Petroleum	16	3,960.0	193.0	9	50	4.9	3.5
Shell Oil	16	4,956.0	326.0	7	33	6.6	5.3
Standard Oil of California	4	7,270.0	378.0	4	22	5.2	4.4
Standard Oil (Ind.)	10	7,500.0	594.0	0	49	7.9	5.3
Standard Oil (Ohio)	5	2,924.0	381.0	6	8	13.0	12.7
Sun Co.	3	4,210.0	143.0	13	59	3.4	2.4
Tenneco	7	3,877.0	155.0	7	40	4.0	3.1
Texaco[d]	4	9,900.0	276.0	−2	−13	2.8	3.2
Unocal (Union Oil)	11	2,680.0	180.1	9	40	6.7	5.2
DIVERSIFIED MANUFACTURERS							
Allied	23	2,800.0	133.0	12	39	4.8	3.8
Aluminum Co. of America	11	1,483.3	97.8	30	nm	6.6	def
Beatrice Foods	5	2,200.0	78.0	−4	−3	3.5	3.5
Borden	18	1,096.2	33.9	17	49	3.1	2.4
Borg-Warner	24	947.8	50.2	17	41	5.3	4.4
Diamond Shamrock	23	1,142.1	59.5	34	1184	5.2	0.5
Du Pont	43	9,330.0	373.0	7	84	4.0	2.3
Eastman Kodak	23	2,140.8	157.8	1	219	7.4	2.3
Engelhard[e]	13	642.7	−15.7	5	def	def	2.7
FMC	37	953.4	42.8	12	36	4.5	3.7
General Electric	13	6,580.0	485.0	8	14	7.4	7.0
Georgia-Pacific[f]	11	1,631.0	51.0	15	70	3.1	2.1
B. F. Goodrich	44	856.2	9.9	17	nm	1.2	def
Kaiser Aluminum[g]	19	814.1	144.6	26	nm	17.8	def
Koppers	34	349.6	−8.7	23	def	def	def
Eli Lilly	24	894.8	146.7	8	8	16.4	16.4
3M	15	1,875.0	175.0	10	11	9.3	9.2
Merck	19	848.6	125.1	10	10	14.7	14.8
NL Industries	24	323.8	0.9	−13	nm	0.3	def
Northwest Industries[h]	24	447.9	14.6	34	873	3.3	0.4
Pfizer	11	919.8	127.7	1	15	13.9	12.2
Tyler	32	216.9	4.0	31	101	1.8	1.2
Uniroyal	29	539.8	17.1	20	375	3.2	0.8
U.S. Steel[i]	6	4,800.0	171.0	23	nm	3.6	def
Upjohn	16	563.0	65.0	16	43	11.5	9.4
Vulcan Materials	31	202.4	-6.7	31	nm	3.3	def

a Excludes major nonrecurring gains or charges to earnings. **b** After-tax income as a percentage of sales. **c** Excludes results of Belco Petroleum in first-quarter 1983. **d** Excludes Getty Oil earnings of $45 million for March 1984. **e** Includes pretax charge of $63.1 million for write-off of certain precious metals refining assets and employee termination expenses. **f** Includes gain of $27 million from settlement of natural gas contract dispute. **g** Includes pretax gains of $44.7 million and negative tax provision of $31.9 million in first-quarter 1983. **h** Restated to exclude Microdot, sold at end of 1983. **i** Includes pretax gains in first-quarter 1984 of $343 million from sale of assets. **nm** = not meaningful. **def** = deficit.

Controversy Surrounding Synfuels Corp. Intensifies

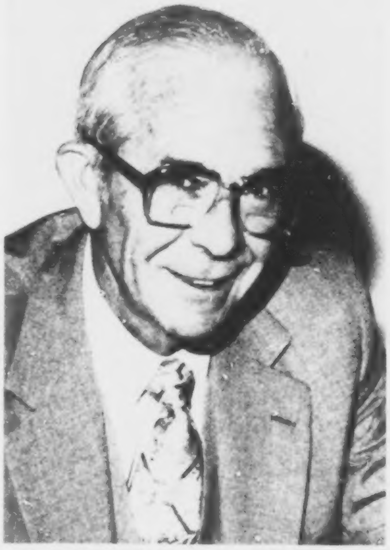
Recent resignation of board members, including president, growing criticism in Congress have hampered corporation's efforts to fund projects

David J. Hanson, C&EN Washington

U.S. Synthetic Fuels Corp. (SFC), set up nearly four years ago by the Carter Administration to help relieve U.S. dependence on foreign energy supplies, has an unenviable record. Criticized for years as not doing anything, the quasi-independent, aid-granting foundation recently moved quickly to set up financial aid for 11 projects—only to be stopped by the controversial resignations of four of the seven members of its board of directors, including its president.

In addition, some members of Congress are trying to wrest away the funds set aside for synthetic fuels assistance. Other members want a total moratorium on project assistance by SFC until Congress can come up with and approve a comprehensive synthetic fuels policy.

Scrutiny of SFC intensified recently because of the controversy surrounding the resignation of Victor M. Thompson Jr., president of SFC. Thompson stepped down from the $135,000-per-year job amid increasing criticism of his dealings with Belton K. Johnson, one of the investors in a Texas tar sands project under consideration by SCF. Thompson apparently had approached Johnson in 1982 for help in supporting the financially ailing Utica Bankshares Corp. of Tulsa, Okla., when Thompson was chairman and chief executive officer of the holding company and while Johnson's project was in a critical stage of consideration by SFC. Thompson took part in SFC decisions regarding the fate of Johnson's project, Chaparrosa Ranch Tar Sands, while the other financial negotiations were in progress, an action considerered unethical.



Thompson: leaves amid ethics probe

Thompson's questionable dealings came to light just two weeks after he was appointed president of SFC in February. The Securities & Exchange Commission charged that the Utica company had overstated its earnings and understated losses while Thompson was its chairman. As more and more details came to light, Thompson revealed he was part of the SEC investigation, and eventually resigned. Thompson insisted he had done nothing wrong and that the possible sale of bank stocks to Johnson was in no way linked to votes on Johnson's synthetic fuels project.

But even the resignation has been controversial. Thompson, after resigning as SFC president, stayed on the board of directors an additional day and voted to approve an award to a Dow Chemical medium-Btu gas project and letters of intent to support the Great Plains Gasification project and the Northern Peat project—nearly $1.8 billion in price guarantees. Thompson resigned from the board the next day.

That extra day spawned severe headaches for SFC. Congressional critics of SFC say it appears as if Thompson stayed on to hurry some projects through before the board was left without a quorum. Rep. Michael Synar (D.-Okla.) says, "It looks like they rushed to get money out the door before incapacitating themselves. At a minimum, it shows a complete disregard for the maintenance of public trust and confidence in SFC's operations." Rep. Howard Volpe (D.-Mich.) calls the action unconscionable and showing "utter disregard for the public."

So now, in addition to the SEC investigation into the Utica Bankshares situation, the House Government Operations Energy Subcommittee will hold a hearing to examine the propriety of SFC's committing funds during that last day of Thompson's board membership. SFC itself, apparently trying to keep its public image from getting any worse, has asked the Justice Department to begin a criminal investigation into Thompson's activities.

Unfortunately for SFC, this scandal is only the latest of its worries. Despite the corporation's increased activity in aiding synthetic fuels projects, Congress had been moving to put some heavy restrictions on SFC's independence. The most prominent of these is a bill, H.R. 4098, introduced by Volpe and cosponsored by about half the House, that would freeze SFC spending until Congress approves some comprehensive synthetic fuels strategy. An identical bill is being considered in the Senate: S. 2358, which was introduced by Sen. William Proxmire (D.-Wis.). The bills' sponsors believe that in this period of enormous budget deficits, it is fiscally irresponsible to allow SFC to commit billions of dollars to unproven projects before there is some kind of overall national synthetic fuels strategy.

In spite of this Congressional acrimony, or, perhaps, because of it, SFC has made some significant awards in the past months. It has an overall plan designed to commit the entire $14.7 billion available to the corporation to various projects by the end of the first quarter of 1985. As of last month, SFC had either made commitments for or signed letters of intent to support 11 projects for financial aid totaling about half that amount. Further awards, however, will be delayed until at least one more member of its board is approved by the Senate. The resignation of Thompson left the board with only three members, one short of the number required to conduct business.

This approval of government assistance for projects has been slow in coming. One of the early criticisms of SFC was that its proposal requirements were so stiff that few projects, if any, had a chance to qualify. Now that projects are receiving aid, complaints have shifted to ones of uncontrolled spending. SFC chairman Edward E. Noble Jr. says SFC has been very careful about putting its program in place, and the proposals now receiving awards are strong, promising projects.

The first of these was the small Cool Water coal gasification project in Daggett, Calif., sponsored by a group of seven firms, including a Japanese consortium. A $120 million price guarantee for the project made by SFC last September met immediate criticism because the small capacity of the facility, about the equivalent of 4300 barrels of oil per day in gas, is more in line with that of a large demonstration plant, rather than the full-size commercial ventures SFC is expected to support. After this beginning, however, SFC was quiet until last month.

In early April, SFC initiated about $4.4 billion for six proposals, including projects for oil shale, gasification, tar sands, and peat. These came almost immediately after chairman of the House Energy & Commerce Committee, John Dingell (D.-Mich.), first urged then-SFC president Thompson to resign because of the SEC investigation. At that April meeting, however, the SFC board of directors voted their full confidence in Thompson and he stayed on. Another major move was made later in the month, when SFC increased the number of commitments to 11, raising the total support to about $7.5 billion.

One of the most controversial decisions was a second award of assistance to the Great Plains coal gasification project in Beulah, N.D. That project already had received a $2.02 billion loan guarantee (being managed by SFC) from the Department of Energy, but its owners had declared more support was needed because of declining oil prices. After receiving a special proposal from the Great Plains project, the SFC board voted to provide up to $790 million in additional price guarantees.

Although the SFC timetable calls for awarding assistance to about a dozen projects by year's end, this is in doubt. The three-member board cannot vote on new awards—indeed, cannot even meet—because it lacks a quorum. President Reagan has said that he will nominate Eric Reichl to the SFC board, but it could be months before the nomination is actually made, and even longer before Senate confirmation. Reichl is a chemical engineer who has worked in the oil and coal industry for more than 40 years.

The SFC officers had hoped that the corporation's increased activity this year would take some of the attention away from its previous inactivity and current personnel problems. However, that doesn't seem to have happened. Congress, led by Volpe and Proxmire, appears determined to halt SFC from spending even the funds it already has promised and to gain more Congressional control over future actions. The large, independent corporation envisioned in 1980 by President Carter to help the U.S. become more independent for energy supplies is likely to remain a vision, the victim of fickle oil prices, high alternative energy costs, and the federal deficit. □

Synfuels Corp. has made at least preliminary commitments to 11 projects in the past six months

Project/ product	Production capacity[a]	Resource	Amount and type of SFC assistance
Cathedral Bluffs/ shale oil	100,000	Colorado shale	$2.18 billion loan & price guarantees
Cool Water/ medium-Btu gas	8,600	Western bituminous coal	$120 million price guarantee
Dow Syngas/ medium-Btu gas	5,172	Western subbituminous coal	$620 million price guarantee
Forest Hill/ heavy oil	1,870	Texas heavy oil	$60 million loan & price guarantees
Great Plains/ high-Btu gas	23,100	North Dakota lignite	$790 million price guarantee[b]
HOP Kern River/ heavy oil	3,891	California heavy oil	$100 million loan & price guarantees
Kentucky Tar Sands/ bitumen	5,600	Eastern tar sands	$543 million price guarantee
Northern Peat Energy/ peat-derived fuel	2,745	Maine peat	$365 million loan & price guarantees
Seep Ridge/ raw shale oil	1,000	Utah shale	$45 million loan & price guarantees
Union Oil Shale I/ upgraded shale oil	10,400	Colorado shale	$400 million price guarantee[c]
Union Oil Shale II/ upgraded shale oil	42,152	Colorado shale	$2.7 billion price guarantee

a Barrels of oil equivalents per day. **b** This is in addition to $2.02 billion loan guarantee from Energy Department. **c** Transferred program from Energy Department. **Source:** U.S. Synthetic Fuels Corp.

Process control fast becoming "process management" Page 7

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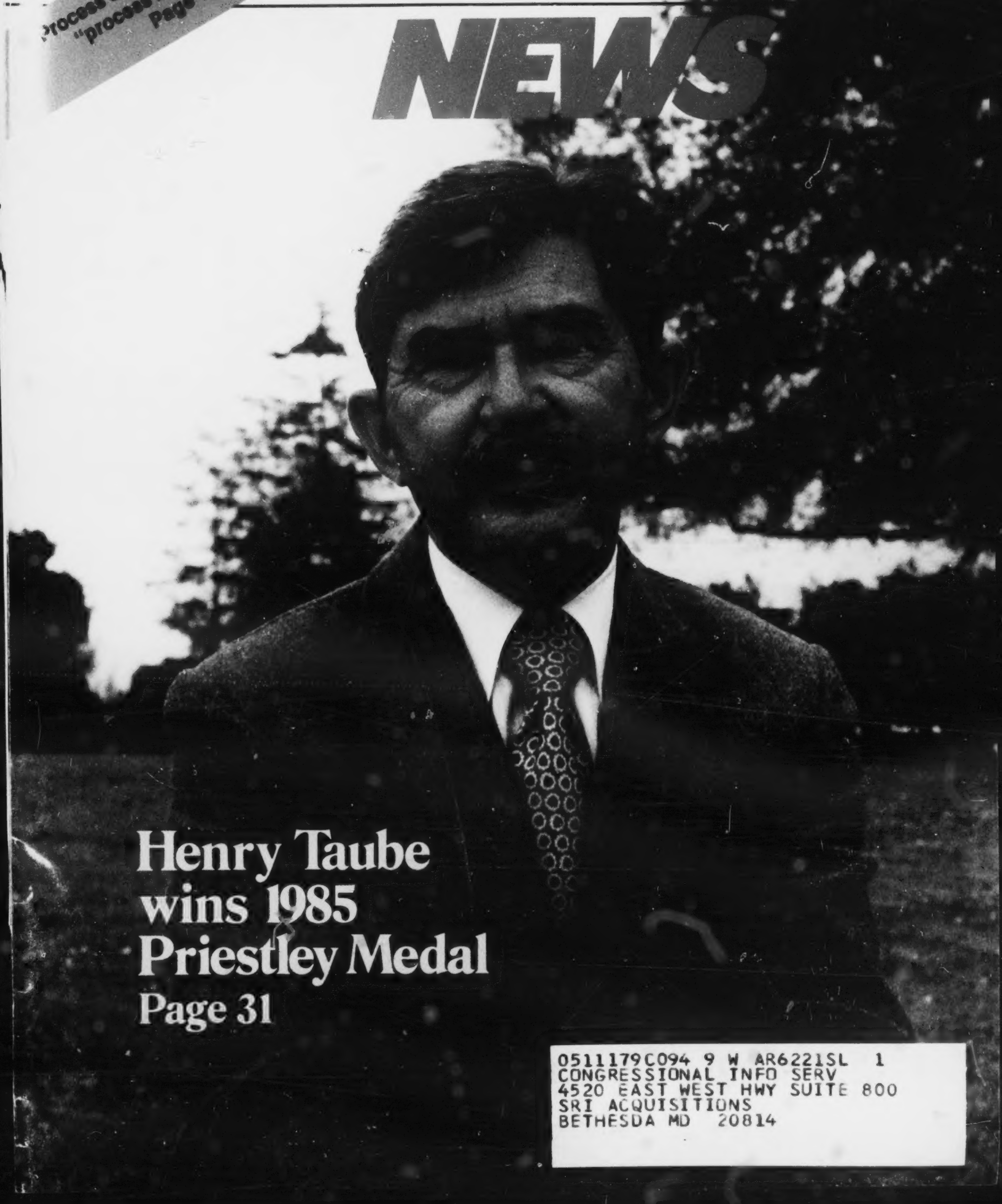
CHEMICAL & ENGINEE

NEWS



Henry Taube wins 1985 Priestley Medal

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CHEMICAL & ENGINEERING NEWS

MAY 21, 1984

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- **USDA's human calorimeter will house volunteers for studies on nutrition.** **Page 5**
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Priestley Medal

Nobel Laureate Henry Taube, professor of chemistry at Stanford University, receives ACS's 1985 Priestley Medal. **Page 31**

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News Focus

Process control concept is now incorporating both supervisory and management levels. **Page 7**

RESEARCH INSTRUMENTS: One fourth of academe's are obsolete

In the past few years a number of studies have emerged bemoaning the shoddy state of academic research equipment, but the evidence has been mostly anecdotal. Now the National Science Foundation has some hard evidence to back up the claim. A new survey finds that one fourth of U.S. academic research equipment is classified as obsolete by the scientists who use it, whereas only 16% is characterized as being state of the art.

This first phase of NSF's National Survey of Academic Research Instruments & Instrumentation needs covers the amount, condition, and cost of existing scientific research equipment systems in calendar year 1982 in three selected fields—computer sciences, physical sciences, and engineering. Data on research equipment systems costing between $10,000 and $1 million provided by department heads and investigators in each field were used to obtain national estimates.

A second phase of the survey covers other fields and is due out next year.

Of the 10,181 instruments in the physical sciences research systems inventory, 1% were not yet in use, 14% were state of the art, and 24% were obsolete; 60% were designated in the survey as other. The figures were similar for the 5839 items in the chemistry inventory—1% not yet in use, 14% state of the art, 22% obsolete, and 63% other.

For engineering, 3% of the 8559 instruments in the inventory were not in use, 18% were state of the art, 24% obsolete, and 55% other. Of the 778 instrument systems in the chemical engineering inventory, 16% were state of the art, 19% obsolete, and 65% other. All were in use. For computer sciences, 6% of the 943 systems were not in use, 17% were obsolete, 18% were state of the art, and 59% other. The percentages for the 639 materials science instruments were 10% obsolete, 16% state of the art, and 74% designated other.

NSF research instrument survey results at a glance

Status
- 2% not yet in use
- 16% state of the art
- 26% obsolete
- 56% other, in use

Age
- 45% 1 to 5 years
- 20% 6 to 10 years
- 31% more than 10 years

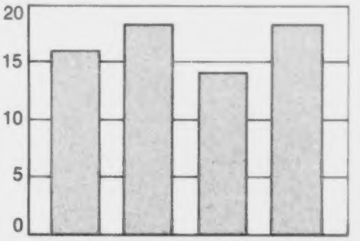
Purchase price
- 58% $10,000 to $24,999
- 31% $25,000 to $74,999
- 11% $75,000 to $1 million

Note: Based on 22,300 items in 1982 research equipment inventory in computer and physical sciences and engineering. **Source:** National Science Foundation

For all three fields combined, 24% of the more expensive research instruments (priced from $75,000 to $1 million) were classified as state of the art—30% in engineering, 22% in the physical sciences, and 18% in computer sciences fell into this category. Nearly all such equipment—98%—in the computer sciences had been acquired since 1978 compared to 80% in the physical sciences and engineering. Also, the study says, 84% of the equipment classified as state of the art was described as being in excellent condition, compared to 42% of all other research instruments in use.

Only 16% of instruments are state of the art

Per cent of existing instrumentation that is state of art



Source: National Science Foundation

In terms of its capability to enable investigators to pursue their major research interests, department heads rated the adequacy of their research equipment as: excellent—8%; adequate—46%; and insufficient—46%. More than 90% reported "important subject areas" of research could not be performed in their units because of lack of needed research instrumentation.

Data for NSF's research instruments survey were collected from a stratified probability sample of 43 universities selected from the 157 largest academic R&D performers. Inventories for all existing research equipment were obtained from institutions' central record-keeping systems and were sent to department heads for verification. More than 90% of both department heads and investigators responded to the survey.

NSF says that a more detailed analytical report covering this survey's results will be published later this year. Meanwhile, the second phase of the study, covering agricultural, biomedical, environmental, and medical sciences is currently under way, with final results expected to be available in 1985. NSF plans to update the complete survey periodically but isn't sure how often an update will be needed. □

Sales, Earnings Up Moderately at Medium-Sized Chemical Firms

Combined operating profits of Second 50 firms rose 6.4% last year on sales gain of 3.5%; profitability increased to an average of 7.9% in 1983

William J. Storck, C&EN New York

The general economic upturn that buoyed the performance of the large chemical companies last year also boosted financial results of medium-sized chemical producers, but not with so much success.

The companies that make up C&EN's list of Second 50 chemical producers (ranked 51 through 100 in terms of chemical sales) rely in large part on making and selling chemical specialties, high-value-added downstream products. Demand for these specialties is not so cyclical as for basic chemicals, which are one of the mainstays of the larger producers. Consequently, the medium-sized companies are more resistant to both recessions and expansions than the larger firms. So it's not surprising that in last year's upturn, sales and earnings increased less for the Second 50 companies than for the Top 50 (C&EN, May 7, page 7).

Combined chemical sales for the Second 50 companies increased last year about 3.5% from 1982 to $17.9 billion, compared to a 6.3% sales gain (to a $101 billion total) for the Top 50. Second 50 chemical operating profits (sales minus costs of goods and general, selling, and administrative expenses), for those companies that report them, increased just 6.4% from the year before to $1.17 billion, compared with an 87% increase (to $6.60 billion) for the Top 50. And based on available data that are comparable year to year, identifiable chemical assets of the medium-sized firms rose an average of 6.8% to $11.96 billion.

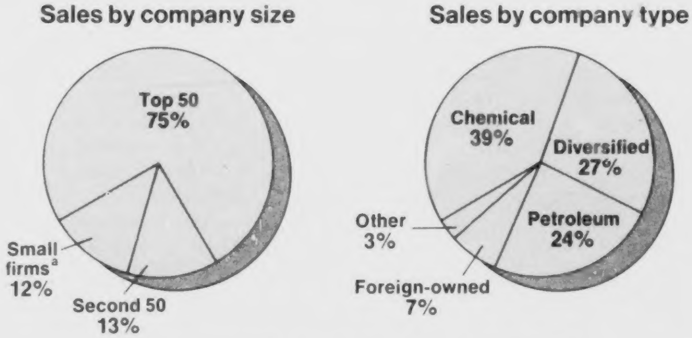
The chemical industry in 1983

The U.S. chemical industry in 1983 paralleled the growth in the economy with about a 7% gain in sales. This increase about equals that of basic chemical production as determined by C&EN in its annual survey of Top 50 chemical products (C&EN, May 7, page 7). This is an indication that there was not much price action in chemicals last year, a view confirmed by many in the chemical industry.

The companies that sell chemical products include not only C&EN's lists of Top 50 and Second 50 chemical producers, but also companies that are too small to be included in the rankings and companies that either do not break out their chemical sales in annual reports or do not report or inadequately report chemical sales.

Of the $137 billion or so in chemical sales in the U.S. last year, the Top 50 producers accounted for about $101 billion or about 75%. The Second 50 producers sold about $18 billion of chemical products, or about 13% of all chemicals sold in the U.S. The remaining 12% was sold by companies too small to make the rankings, and companies that do not report chemical sales.

By company type, about $52.2 billion, or 39%, of chemical products was sold by chemical companies—firms with chemicals as their largest business segments. Diversified firms—companies that have the majority of their sales in products other than chemicals, petroleum, or natural gas—sold more than $35.1 billion in chemicals, or 26% of the total. Petroleum or natural gas producers sold more than $33 billion in chemicals for almost 25% of the total. Foreign-owned companies not disclosing chemical sales accounted for about 7%, whereas U.S. firms that did not break out chemical revenues made up about 3% of total sales.



Sales by company size

Sales by company type

Total 1983 U.S. chemical sales = $137 billion

[a] Also includes companies not disclosing chemical sales

Operating results improved for Second 50 chemical producers in 1983

Rank 1983	Rank 1982[a]		Chemical sales 1983 ($ millions)	Change from 1982	Chemical sales as % of total sales	Industry classification	Chemical operating profits[b] ($ millions)	Change from 1982	Chemical operating profits as % of total operating profits	Operating profit margin[c]	Identifiable chemical assets ($ millions)	Chemical assets as % of total assets	Operating return on chemical assets[d]
51	53	**Pennwalt**	$605	4.2%	62.0%	Basic chemicals	$ 43	−7.1%	58.1%	7.1%	$463	53.1%	9.3%
52	56	**Uniroyal**	593	15.0	29.1	Rubber products	65	54.9	40.6	11.0	465	31.3	14.0
53	48	**Kaiser Aluminum**	582	−9.3	20.4	Nonferrous metals	24	−43.9	def	4.2	488	13.9	5.0
54	50	**Esmark**[e]	580[f]	−7.8	14.1	Food	29	25.6	11.0	5.1	347	11.1	8.5
55	58	**Witco Chemical**	571	11.3	41.2	Specialty chemicals	54	40.2	36.2	9.5	276	37.7	19.6
56	54	**Standard Oil (Ohio)**	566	2.2	4.7	Petroleum	−3	def	def	def	642	3.9	def
57	55	**Koppers**	555[f]	3.7	35.4	Diversified	7	−14.8	8.4	1.3	316	26.9	2.3
58	45	**Farmland Industries**	542	−18.4	11.5	Agricultural supplies	−55	def	def	def	447	26.2	def
59	63	**National Starch**	508	8.8	67.1	Specialty chemicals	na	na	na	na	na	na	na
60	61	**NL Industries**	470	−1.4	33.8	Petroleum services	63	4.7	def	13.4	317	16.5	19.8
61	56	**Sun Co.**	467	−9.5	3.0	Petroleum	na	na	na	na	na	na	na
62	64	**International Flavors**	461	2.9	100.0	Specialty chemicals	111	9.3	100.0	24.0	432	94.2	25.6
63	62	**Cabot**[g]	460	−2.4	29.5	Specialty metals	44	−29.8	26.5	9.5	259	19.8	16.9
64	67	**Beatrice Foods**	453	6.1	20.3	Food	66	32.0	8.2	14.6	na	na	na
65	—	**Morton Thiokol**[h]	448	132.0	29.7	Diversified	47	168.2	27.3	10.5	533	46.3	8.9
66	65	**Freeport-McMoRan**	441	1.2	56.0	Agricultural chemicals	74	−21.0	52.0	16.8	235	16.6	31.6
67	60	**Kerr-McGee**	439	−10.1	12.5	Petroleum	−27	def	def	def	630	16.5	def
68	66	**Polysar**	436	1.5	100.0	Basic chemicals	na	na	na	na	na	na	na
69	72	**H. B. Fuller**[i]	426	28.2	100.0	Specialty chemicals	33	31.6	100.0	7.8	226	100.0	14.7
70	68	**Henkel**	400	1.5	100.0	Specialty chemicals	na	na	na	na	na	na	na
71	69	**Pfizer**	394	0.9	10.5	Drugs	5	def	0.7	1.3	394	10.0	1.3
72	70	**Liquid Air**	390	5.1	84.8	Basic chemicals	49	2.1	104.1	12.5	465	86.8	10.5
73	71	**InterNorth**	374	9.9	7.5	Natural gas	27	146.3	5.3	7.1	404	8.1	6.6
74	76	**GAF**	323	9.8	46.2	Specialty chemicals	65	16.4	211.1	20.0	198	47.8	32.6
75	84	**American Petrofina**	310	23.2	15.0	Petroleum	5	def	6.1	1.7	178	12.7	2.9
76	78	**Houston Natural Gas**[j]	305	9.9	10.3	Natural gas	34	7.0	10.8	11.0	387	14.2	8.7
77	74	**Tyler**	304	0.8	31.6	Diversified chemicals	22	51.7	31.7	7.2	158	31.6	13.9
78	85	**Soltex**	300	20.0	100.0	Basic chemicals	na	na	na	na	na	na	na
79	77	**Big Three Industries**	294	3.6	43.9	Petroleum services	71	−11.2	67.5	24.1	538	49.0	13.1
80	81	**Upjohn**	291	8.6	15.9	Drugs	−21	def	def	def	180	10.2	def
81	75	**Rhône-Poulenc**	290	−3.3	100.0	Specialty chemicals	na	na	na	na	na	na	na
82	87	**Engelhard**	273	10.2	24.9	Specialty metals	56	13.4	49.9	20.4	264	30.4	21.1
83	79	**Petrolite**[e]	267	−3.0	92.7	Specialty chemicals	33	−24.6	97.6	12.3	153	73.1	21.5
84	73	**Mississippi Chemical**[h]	263	−19.3	100.0	Farm cooperative	4	1333.3	100.0	1.6	343	100.0	1.3
85	83	**Emhart**	259	2.2	15.3	Machinery	24	2.6	15.6	9.2	113	11.1	21.1
86	82	**Vulcan Materials**	256	−2.7	31.2	Nonmetallic minerals	15	−67.3	16.4	5.7	na	na	na
87	91	**Beker Industries**	253	20.2	100.0	Agricultural chemicals	1	def	100.0	0.4	327	100.0	0.3
88	88	**Chemed**	252	9.4	92.8	Specialty chemicals	35	10.5	92.3	13.8	134	67.9	26.0
89	86	**SCM**[h]	251[f]	0.8	15.1	Paint	15	−32.6	16.5	6.0	267	24.0	5.7
90	80	**Terra Chemicals**	247	−9.5	100.0	Agricultural chemicals	na	na	na	na	173	100.0	na
91	93	**Aluminum Co. of America**	241	17.0	4.6	Nonferrous metals	na	na	na	na	na	na	na
92	94	**Ferro**	240[f]	16.9	38.8	Specialty materials	17	107.1	32.5	7.2	77	20.9	22.7
93	98	**Great Lakes Chemical**	226	33.2	100.0	Specialty chemicals	39	53.1	100.0	17.3	227	100.0	17.3
94	90	**Loctite**	216	−0.3	100.0	Specialty chemicals	29	17.3	100.0	13.5	213	100.0	13.7
95	89	**Martin Marietta**	214	−3.8	5.5	Aerospace	35	84.2	13.0	16.4	197	7.2	17.7
96	92	**Stepan Chemical**	207	−0.6	100.0	Specialty chemicals	11	20.7	100.0	5.4	145	100.0	7.7
97	—	**Essex Chemical**	169	11.2	100.0	Basic chemicals	17	−23.0	100.0	9.9	116	79.8	14.4
98	95	**Agway**	162	−16.0	4.3	Farm cooperative	na	na	na	na	na	na	na
99	—	**UGI Corp.**	149	−21.2	22.3	Natural gas	0	def	def	def	117	21.0	def
100	—	**Sterling Drug**	136	2.3	7.2	Diversified	7	56.5	2.8	5.3	112	7.6	6.4

a Revised. **b** Sales minus administrative expense and cost of selling. **c** Operating profit from chemicals as a percentage of chemical sales. **d** Operating profit as a percentage of identifiable assets. **e** Fiscal year ended Oct. 31, 1983. **f** Chemical sales include significant amounts of nonchemical products. **g** Fiscal year ended Sept. 30, 1983. **h** Fiscal year ended June 30, 1983. **i** Fiscal year ended Nov. 30, 1983. **j** Fiscal year ended July 31, 1983. **na** = not available. **def** = deficit.

Hence, operating profit margins (chemical operating profits as a percentage of chemical sales) for the Second 50 firms rose to an average of 7.9% in 1983 from 7.7% in 1982. And return on chemical assets for firms reporting consistent data increased to 8.9% from 8.7% the year before. Although these increases seem slight, the profitability is much higher than the average 6.7% profit margin and 7.2% return on assets for the Top 50 companies.

The largest increase in chemical sales among the Second 50 was registered by Morton Thiokol, with 132%. But this figure is misleading. Last year the company was omitted from the list, because it had not restated its results to include Thiokol's sales after the Morton-Norwich-Thiokol merger. This year, the sales from the combined companies are being compared with sales that include only part of the combined company in 1982.

After Morton Thiokol, the largest increase was reported by Great Lakes Chemical, whose sales rose 33% in 1983 over the year before. Other large sales increases were posted by H. B. Fuller, up 28%; and American Petrofina, up 23%.

In spite of the recovery, chemical sales increases were by no means universal. Of the Second 50 companies, 18 posted declines. The largest drop was 21% at UGI Corp., which is new to the list this year. Mississippi Chemical posted a 19% decline, and Farmland Industries an 18% decline; both are producers of agricultural chemicals, hard hit by government programs in 1983.

Four companies are new to the Second 50 list this year. In addition to UGI Corp., Morton Thiokol is back after including Thiokol's sales. It would have been on the list last year if these results had some way been restated. And for the first time Essex Chemical and Sterling Drug are ranked this year.

Of the companies that dropped off the list, only one—First Mississippi, another agricultural chemical firm—was because of declining sales. Airco, now called BOC Group Inc., no longer discloses chemical sales, and others such as Getty and El Paso have been acquired by other companies.

There was lots of movement in the rankings of the companies. Of those that were on the list in 1982, only one—Chemed—held the same rank (88th) in 1983. Of the remaining 45 firms that were on the list both years, 27 fell in ranking from 1982 to 1983, and 18 moved up on the list.

The largest fall in rank was registered by Farmland Industries, which dropped to 58th in 1983 from 45th on the list of Top 50 companies the year before. This was followed by Mississippi Chemical, which slipped to 84th from 73rd, and Terra Chemical, to 90th from 80th. The largest increases in ranking were recorded by Great Lakes Chemical, to 93rd from 98th; Soltex, to 78th from 85th; and American Petrofina, to 75th from 84th. □

Second 50 fared worse than Top 50 in growth in 1983

Last year was a year of recovery from the profits-withering recession. However, larger chemical producers registered a stronger recovery in sales and operating profits than the medium-sized companies. But the medium-sized firms outperformed the larger ones in terms of profitability.

Sales growth for the Second 50 chemical producers averaged just 3.5% in 1983 over the year before, whereas earnings growth averaged, for the companies that report operating profits, 6.4%. By contrast, the Top 50 companies recorded an average sales growth of 6.3%, and an average earnings increase of 87%.

Since the Top 50 companies are largely producers of highly cyclical basic chemicals, it is no wonder that their growth reflects the cyclical nature of their products. The Second 50 firms by comparison are more heavily involved in lower-volume, higher-value-added specialty chemicals, which are not so cyclical as basic chemicals, and, because they are more downstream, tend to lag economic cycles. And because the products of the Second 50 are higher-value-added than the commodities produced by many of the Top 50 firms, it is not surprising that the group of medium-sized producers leads in profitability. Operating profits as a percentage of sales for the larger firms moved up to an average of 6.7% in 1983 from 3.8% the year before. Operating profit margins for the Second 50 increased to 7.9% from 7.7% in 1982.

The same pattern holds for return on identifiable assets: Larger producers registered an increase to 7.2% in 1983 from 4.3% in 1982, whereas medium-sized producers had an increase to 8.9% from 8.7% the year before.

Medium-sized firms increased their asset base in chemicals last year; the larger companies did not. Identifiable chemical assets for those medium-sized producers that split them out increased 6.8% in 1983 over the year before, whereas the chemical assets base of the larger producers declined an average of 2.4% during the year.

For the total 100 companies in 1983, chemical sales increased 7.3% and earnings jumped 67%, increasing the profit margin to 6.8% from 4.4% the year before. Assets for the group declined 1.3% and return on assets increased to 7.5% in 1983 from 4.9% the year before.

	Second 50	Top 50	Combined 100
Chemical sales, change from 1982	3.5%	6.3%	7.3%
Chemical operating profits, change from 1982	6.4	87	67.4
Chemical assets, change from 1982	6.8	−2.4	−1.3
Chemical operating profit margin, 1983	7.9	6.7	6.8
Return on identifiable chemical assets, 1982	8.9	7.2	7.5
	Number of companies on list		
Chemical companies	20	23	43
Petroleum and natural gas producers	7	13	20
Diversified and other	23	14	37
Foreign[a]	6	5	11

[a] Also included in above categories.

C&EN's Top 100 chemical producers ranked five ways

	Chemical sales			Chemical operating profit			Chemical operating profit margin			Identifiable chemical assets			Return on chemical assets		
		Rank			Rank			Rank			Rank			Rank	
	1983	1983	1982	1983	1983	1982	1983	1983	1982	1983	1983	1982	1983	1983	1982
Agway	$ 162	98	95	na	—	—	na	—	—	na	—	—	na	—	—
Air Products	1,412	20	21	$ 196	11	7	13.9%	12	13	$1654	13	15	11.8%	31	26
Allied	2,337	11	14	224	8	15	9.6	31	43	1299	18	12	17.2	18	39
Aluminum Co. of America	241	91	93	na	—	—	na	—	—	na	—	—	na	—	—
American Cyanamid	1,719	18	18	106	23	18	6.2	49	44	1275	19	19	8.3	45	38
American Hoechst	1,222	26	28	na	—	—	na	—	—	na	—	—	na	—	—
American Petrofina	310	75	84	5	75	70	1.7	69	—	178	77	71	2.9	65	—
Ashland Oil	1,208	27	27	1	77	49	0.1	75	58	423	55	55	0.2	73	42
Atlantic Richfield	2,550	10	11	64	36	83	2.5	67	—	2603	8	8	2.5	67	—
Badische	671	48	59	30	56	71	4.4	61	—	513	47	48	5.7	57	—
BASF Wyandotte	1,034	35	38	20	64	69	1.9	68	—	726	38	37	2.7	66	—
Beatrice Foods	453	64	67	66	32	34	14.6	11	20	na	—	—	na	—	—
Beker Industries	253	87	91	1	77	74	0.4	74	—	327	63	63	0.3	72	—
Big Three Industries	294	79	77	71	28	23	24.1	1	1	538	45	46	13.1	28	15
Borden	1,295	24	25	138	16	22	10.6	25	40	1325	17	20	10.4	35	43
Borg-Warner	826	40	52	110	21	33	13.3	18	33	365	60	64	30.2	3	14
Cabot	460	63	62	44	45	27	9.5	32	15	259	69	67	16.9	19	5
Celanese	3,261	6	7	214	9	43	6.6	46	62	2869	7	7	7.5	47	58
CF Industries	862	39	37	34	52	84	4.0	64	—	1013	29	30	3.4	64	—
Chemed	252	88	88	35	49	48	13.8	13	14	134	82	82	26.0	5	2
Ciba-Geigy	1,290	25	23	na	—	—	na	—	—	na	—	—	na	—	—
Diamond Shamrock	942	37	33	12	70	26	1.3	71	41	1063	25	28	1.1	71	42
Dow Chemical	8,875	2	2	573	2	5	6.5	47	57	8193	1	1	7.0	50	53
Dow Corning	763	43	46	68	29	32	9.0	37	35	na	—	—	na	—	—
Du Pont	11,607	1	1	1144	1	2	9.9	28	52	7591	2	2	15.1	22	48
Eastman Kodak	2,285	13	12	214	9	6	9.4	34	27	2124	11	11	10.1	36	30
Eli Lilly	727	46	42	98	24	12	13.5	15	6	793	36	35	12.3	30	13
Emhart	259	85	83	24	60	54	9.2	36	29	113	85	83	21.1	10	7
Engelhard	273	82	87	56	39	35	20.4	3	4	264	68	70	21.1	10	9
Esmark	580	54	50	29	57	54	5.1	58	53	347	61	59	8.5	44	44
Essex Chemical	169	97	—	17	65	—	9.9	28	—	116	84	—	14.4	24	—
Ethyl	1,478	19	20	156	14	10	10.6	25	25	901	33	32	17.3	16	18
Exxon	8,439	3	3	348	4	37	4.1	63	64	4852	4	5	7.2	48	59
Farmland Industries	542	58	45	−55	89	72	def	—	—	447	53	47	def	—	—
Ferro	240	92	94	17	65	64	7.2	42	51	77	87	81	22.7	8	41
FMC	1,296	23	22	169	13	11	13.0	19	23	1063	25	25	15.9	20	20
Freeport-McMoRan	441	66	65	74	26	20	16.8	7	3	235	70	65	31.6	2	1
H. B. Fuller	426	69	72	33	54	52	7.8	40	38	226	72	71	14.7	23	25
GAF	323	74	76	65	34	30	20.0	4	5	198	74	76	32.6	1	3
Georgia-Pacific	683	47	51	64	36	24	9.4	34	19	1023	28	27	6.3	54	39
B. F. Goodrich	1,133	30	34	44	45	66	3.9	65	66	1214	20	24	3.6	62	62
W. R. Grace	2,760	9	9	324	5	3	11.7	22	20	1641	14	14	19.7	13	11
Great Lakes Chemical	226	93	98	39	48	50	17.3	6	12	227	71	73	17.3	16	22
Gulf Oil	1,748	17	16	−76	91	85	def	—	—	1009	30	21	def	—	—
Henkel	400	70	68	na	—	—	na	—	—	na	—	—	na	—	—
Hercules	2,007	15	15	121	18	25	6.0	51	53	1204	21	17	10.0	37	50
Houston Natural Gas	305	76	78	34	52	47	11.0	23	23	387	58	56	8.7	43	36
International Flavors	461	62	64	111	20	17	24.0	2	2	432	54	52	25.6	6	6
International Minerals	997	36	35	156	14	8	15.7	10	9	1377	16	18	11.4	32	23
InterNorth	374	73	71	27	59	61	7.1	44	56	404	56	57	6.6	52	60

	Chemical sales			Chemical operating profit			Chemical operating profit margin			Identifiable chemical assets			Return on chemical assets		
	—	Rank			Rank			Rank			Rank			Rank	
	1983	1983	1982	1983	1983	1982	1983	1983	1982	1983	1983	1982	1983	1983	1982
Kaiser Aluminum	582	53	48	24	60	39	4.2	62	42	488	49	45	5.0	60	34
Kerr-McGee	439	67	60	−27	87	73	def	—	—	630	43	39	def	—	—
Koppers	555	57	55	7	73	64	1.3	71	61	316	65	61	2.3	68	54
Liquid Air	390	72	70	49	43	36	12.5	20	16	465	50	50	10.5	34	28
Loctite	216	94	90	29	57	53	13.5	15	22	213	73	74	13.7	27	24
Lubrizol	800	41	41	109	22	16	13.6	14	17	683	40	42	15.9	20	12
Martin Marietta	214	95	89	35	49	58	16.4	9	32	197	75	69	17.7	15	36
Merck	606	50	49	52	41	29	8.6	38	28	592	44	43	8.8	42	28
Mississippi Chemical	263	84	73	4	76	67	1.6	70	67	343	62	58	1.3	69	62
Mobay	1,300	22	30	66	32	76	5.1	58	—	1168	22	22	5.7	57	—
Mobil	2,331	12	13	−16	85	62	def	—	64	2266	10	10	def	—	61
Monsanto	5,771	4	4	568	3	1	9.8	30	26	4498	5	4	12.6	29	31
Morton Thiokol	448	65	—	47	44	—	10.5	27	—	533	46	—	8.9	41	—
Nalco Chemical	659	49	47	118	19	19	17.8	5	11	489	48	49	24.0	7	8
National Distillers	785	42	44	68	29	46	8.6	38	46	683	40	40	9.9	38	46
National Starch	508	59	63	na	—	—	na	—	—	na	—	—	na	—	—
NL Industries	470	60	61	63	38	28	13.4	17	18	317	64	62	19.8	12	10
Occidental Petroleum	1,137	28	24	−12	82	50	def	—	59	985	32	23	def	—	56
Olin	1,111	33	36	68	29	30	6.1	50	45	1002	31	34	6.8	51	45
Pennwalt	605	51	53	43	47	37	7.1	44	35	463	52	51	9.3	39	27
Petrolite	267	83	79	33	54	39	12.3	21	10	153	80	80	21.5	9	4
Pfizer	394	71	69	5	75	68	1.3	71	—	394	57	54	1.3	69	—
Phillips Petroleum	2,255	14	10	83	24	54	3.7	66	63	1413	15	16	5.9	55	57
Polysar	436	68	66	na	—	—	na	—	—	na	—	—	na	—	—
PPG Industries	882	38	39	51	42	43	5.8	54	49	1152	23	26	4.4	61	52
Reichhold Chemicals	747	44	43	35	49	59	4.6	60	60	371	59	60	9.3	39	51
Rhône-Poulenc	290	81	75	na	—	—	na	—	—	na	—	—	na	—	—
Rohm & Haas	1,808	16	17	298	6	9	16.5	8	30	1038	27	29	28.7	4	19
SCM	251	89	86	15	67	57	6.0	51	30	267	67	66	5.7	57	35
Shell Oil	3,227	7	6	130	17	82	4.0	64	—	3759	6	6	3.5	63	—
Soltex	300	78	85	na	—	—	na	—	—	na	—	—	na	—	—
Standard Oil (Ind.)	2,906	8	8	173	12	14	6.0	51	47	2445	9	9	7.1	49	49
Standard Oil (Ohio)	566	56	54	−3	81	78	def	—	—	642	42	44	def	—	—
Standard Oil of Calif.	1,059	34	32	−12	82	75	def	—	—	780	37	36	def	—	—
Stauffer Chemical	1,340	21	19	−14	84	4	def	—	7	2048	12	13	def	—	16
Stepan Chemical	207	96	92	11	72	62	5.4	56	49	145	81	78	7.7	46	47
Sterling Drug	136	100	—	7	73	—	5.3	57	—	112	86	—	6.4	53	—
Sun Co.	467	61	56	na	—	—	na	—	—	na	—	—	na	—	—
Terra Chemicals	247	90	80	na	—	—	na	—	—	173	78	75	na	—	—
Texaco	1,137	28	26	−65	90	77	def	—	—	895	34	33	def	—	—
Tyler	304	77	74	22	62	59	7.2	42	47	158	79	79	13.9	26	33
UGI Corp.	149	99	—	0	80	—	def	—	—	117	83	—	def	—	—
Union Carbide	3,912	5	5	285	7	13	7.3	41	55	4917	3	3	5.8	56	55
Uniroyal	593	52	56	65	34	42	11.0	24	34	465	50	53	14.0	25	32
Unocal Corp.	1,133	30	29	74	26	21	6.5	47	37	699	39	38	10.6	33	21
Upjohn	291	80	81	−21	86	81	def	—	—	180	76	77	def	—	—
U.S. Steel	1,128	32	31	−27	87	80	def	—	—	1130	24	41	def	—	—
Vulcan Materials	256	86	82	15	67	39	5.7	55	8	na	—	—	na	—	—
Williams Cos.	740	45	40	1	77	79	0.1	75	—	894	35	31	0.1	74	—
Witco Chemical	571	55	58	54	40	43	9.5	32	39	276	66	68	19.6	14	17

Note: Companies with negative profitability are not included in rankings and companies not included in 1982's listing are not ranked for that year. **na** = not available. **def** = deficit.

Polymer output recouped much of 1982's losses

David Webber, C&EN New York

Accounting for the sharp earnings gains of the past few quarters, chemical company chief executives in many cases have been giving much of the credit to strong performance by their polymer business lines. Since the chemical industry recovery began, in fact, analysts have pointed to plastics and fibers as the leading elements in the rebound. Now C&EN's survey of polymer production in 1983 provides statistical proof of that characterization.

Last year, polymer output recovered sharply. Production of all types of plastics increased 16% after a 7.1% drop in 1982. Production of synthetic fibers shot up 17% after plummeting 19% the year before. And even output of synthetic rubber, the low-energy performer of the polymers sector, rose a solid 8.1% following a 9.5% decline in the 1982 slump. Overall, polymer production in the U.S. climbed almost 16% last year. The year before, it had fallen 9.9%.

As a result, polymer production regained much of the ground it lost during the recession year. In total, output of some 48.7 billion lb was higher than for any other year in history except 1979. That statistic distinctly underlines the quality of the polymers' recovery compared to that of basic chemicals. For C&EN's Top 50 chemical products, by contrast, 1983 total output remained far short of that of recent years despite a decent rebound. It is only back in 1976, in fact, that it is possible to find the most recent annual production total (other than that for 1982) that is lower than 1983's (C&EN, May 7, page 7).

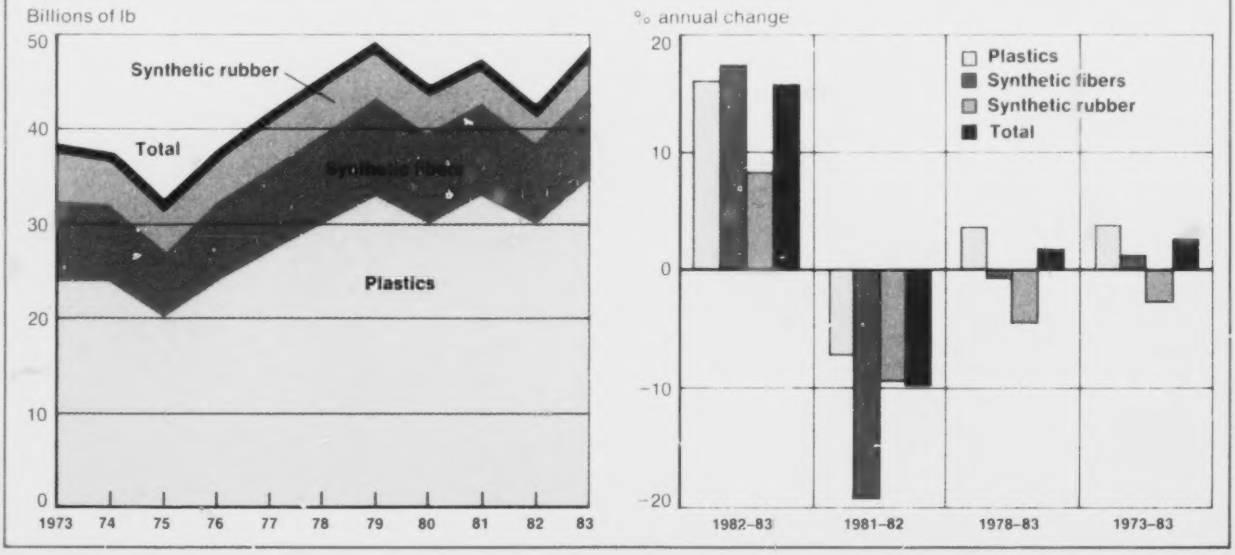
Still, polymer output looks less smashing in a longer perspective. Plastics, true, have managed a respectable compound growth rate for production of 3.4% over the past five years and 3.9% over the past 10 years. But fiber production has declined at an annual rate of 0.6% during the past half-decade. Since 1973, fiber output has expanded at an annual rate of just 1.1%. Synthetic rubber production statistics look even less exciting—declining at an annual 4.4% pace between 1978 and 1983 and shrinking some 2.6% a year over the past decade.

It is a measure of the harshness of the economic climate over the past five years that, whereas only six of 23 polymer products show average annual production declines since 1973, output of 11 of the products has shrunk since 1978. Among synthetic fibers, for example, both polyester and nylon output grew slightly over the 10-year span but have been declining since 1978. The same goes for polybutadiene among the synthetic elastomers. In the healthier plastics segment, production has increased for all products since 1973. Since 1978, only unsaturated polyester and melamine resins have decreased in output.

During 1983, the largest gain by a single segment was a 22% rise recorded by thermosetting resins, which account for some 15% of plastics poundage. Production of phenol, the most important thermoset, and other tar acid resins increased 24% in a year in which housing starts rose from 1.06 million to 1.70 million and the Federal Reserve Board's industrial production index for plywood, a major market for phenol products, shot up 29%. Among the thermoplastics, whose overall output rose 15% last year, the outstanding performers were polypropylene, polystyrene, and high-density polyethylene. In 1983, the automobile production index, an important indicator of plastic markets, rocketed 36%.

The big 18% increase in noncellulosic synthetic fiber production came in a year in which the industrial

Fibers led general recovery in production of polymers in 1983



Output of plastics, fibers, and rubber all rose in 1983

	Billions of lb		Common units					Average annual growth			
Production	1983	1982	1983	1982	1981	1978	1973	1982-83	1981-82	1978-83	1973-83
PLASTICS (millions of lb)											
Thermosetting resins	**5.25**	**4.31**	**5,247**	**4,313**	**5,010**	**4,449**	**3,698**	**21.7%**	**−13.9%**	**3.4%**	**3.6%**
Phenol and other tar acid resins	2.48	2.01	2,477	2,006	2,333	1,617	1,387	23.5	−14.0	8.9	6.0
Urea resins	1.17	1.00	1,172	998	1,165	1,122	867	17.4	−14.3	0.9	3.1
Polyesters (unsaturated)	1.08	0.87	1,084	865	997	1,209	1,051	25.3	−13.2	−2.2	0.3
Epoxies (unmodified)	0.33	0.29	334	286	336	299	223	16.8	−14.9	2.2	4.1
Melamine resins	0.18	0.16	180	158	179	202	170	13.9	−11.7	−2.3	0.6
Thermoplastic resins	**29.78**	**25.90**	**29,781**	**25,896**	**27,523**	**25,186**	**20,186**	**15.0%**	**−5.9%**	**3.4%**	**4.0%**
Low-density polyethylene	8.04	7.50	8,041	7,503	7,693	7,111	5,803	7.2	−2.5	2.5	3.3
PVC and copolymers	6.07	5.33	6,067	5,326	5,707	5,723	4,562	13.9	−6.7	1.2	2.9
High-density polyethylene	5.69	4.93	5,689	4,928	4,695	4,201	2,637	15.4	5.0	6.3	8.0
Polystyrene and copolymers	5.55	4.66	5,551	4,662	5,473	5,077	5,022	19.1	−14.8	1.8	1.0
Polypropylene and copolymers	4.43	3.48	4,433	3,477	3,955	3,074	2,162	27.5	−12.1	7.6	7.4
TOTAL[a]	**35.03**	**30.21**	**35,028**	**30,209**	**32,533**	**29,635**	**23,884**	**16.0%**	**−7.1%**	**3.4%**	**3.9%**
SYNTHETIC FIBERS (millions of lb)											
Cellulosics	**0.60**	**0.58**	**603**	**584**	**771**	**905**	**1,357**	**3.3%**	**−24.3%**	**−7.8%**	**−7.8%**
Rayon	0.38	0.39	375	388	509	597	895	−3.4	−23.8	−8.9	−8.3
Acetate[b]	0.23	0.20	228	196	262	308	462	16.3	−25.2	−5.8	−6.8
	8.69	**7.34**	**8,693**	**7,341**	**9,023**	**8,691**	**6,998**	**18.4%**	**−18.6%**	**0.0%**	**2.2%**
Polyester	3.54	3.17	3,543	3,168	4,173	3,800	2,901	11.8	−24.1	−1.4	2.0
Nylon[c]	2.42	1.93	2,418	1,927	2,333	2,550	2,175	25.5	−17.4	−1.1	1.1
Glass fiber	1.17	0.90	1,166	899	1,041	923	688	29.7	−13.6	4.8	5.4
Olefin	0.90	0.72	895	723	785	692	492	23.8	−7.9	5.3	6.2
Acrylic[d]	0.67	0.62	671	624	691	726	742	7.5	−9.7	−1.6	−1.0
TOTAL[a]	**9.30**	**7.93**	**9,296**	**7,925**	**9,794**	**9,596**	**8,355**	**17.3%**	**−19.1%**	**−0.6%**	**1.1%**
SYNTHETIC RUBBER (thousands of metric tons)											
Styrene-butadiene[e]	1.99	1.93	904	876	1,032	1,395	1,512	3.2%	−15.1%	−8.3%	−5.0%
Polvbutadiene	0.73	0.64	333	288	342	377	332	15.6	−15.8	−2.5	0.0
Ethylene-propylene	0.39	0.27	175	123	178	174	118	42.3	−30.9	0.1	4.0
Neoprene	0.25	0.26	115	119	143	161	266	−3.4	−16.8	−6.5	−8.0
Nitrile	0.12	0.10	55	45	66	73	83	22.2	−31.8	−5.5	−4.0
Other[f]	0.87	0.83	396	378	261	292	274	4.8	44.8	6.3	3.8
TOTAL[a]	**4.36**	**4.03**	**1,978**	**1,829**	**2,022**	**2,472**	**2,585**	**8.1%**	**−9.5%**	**−4.4%**	**−2.6%**

[a] Totals are for those products listed. Totals may not add because of rounding. [b] Includes diacetate and triacetate yarn. Does not include cigarette filters. [c] Includes aramid. [d] Includes modacrylic. [e] Excludes high-styrene latex. [f] Includes butyl, polyisoprene, chlorosulfonated polyethylene, polyisobutylene, and acrylo, fluoro, polysulfide, and silicone elastomers. Before 1982, butyl and polyisoprene were reported separately; they have been added retroactively to "other" here.

production index for textile mill products rose 13%. Nylon output's 26% explosion reflected a 23% rise in the government's carpeting production index. The other big increases in synthetic fiber output were registered by glass and olefin fibers. The Federal Reserve Board's index of man-made fiber production rose 16% in 1983.

Production of synthetic rubber products reflected increases in the government's production indexes as well. The index of tire output, for instance, climbed 11%; that for rubber products, excluding tires, rose 5.5% in 1983. Among the elastomers, the biggest increase in production was notched by ethylene-propylene rubber, up 42% last year.

The production increases throughout the polymers industry helped raise capacity utilization rates. Low-density polyethylene capacity utilization increased from 76% of nameplate capacity in late 1982 to 79.6% in 1983. Utilization of high-density polyethylene nameplate capacity rose from 82% in 1982 to 90.3% last year.

For polyvinyl chloride, the utilization rate jumped from 59% in 1982 to 68% in 1983. For polypropylene, the capacity utilization rate rose from 61% in 1982 to 86.9% last year.

Utilization of synthetic fiber production capacity increased even more sharply overall. Output of polyester fiber, for example, rose to 82.3% last year. For nylon, the 1983 capacity utilization rate reached 83.7%. Production of olefin fibers, which was using up some 60% of nameplate capacity in late 1982, required nearly 82% of total capacity in 1983.

With the improvement in polymer capacity utilization rates has come an increase in announcements of plant expansions. Northern Petrochemical, for example, plans to expand capacity of its Morris, Ill., polypropylene facility to 220 million lb per year via debottlenecking. Shintech is increasing the capacity of its Freeport, Tex., polyvinyl chloride unit to 1 billion lb per year, and, in February, Air Products finished boosting capacity of its PVC plants to 500 million lb per year. ☐

Drug profits climb 12% overall in mixed results

Major pharmaceutical houses recorded a solid 12% gain in earnings in this year's first quarter, but results varied widely. Several companies in a group of 17 achieved record sales and earnings, but three reported a profit decline. For the group, sales increased 6%. Overall profitability, measured as after-tax income as a percentage of sales, rose to 11.3% in this year's first quarter from 10.7% in first-quarter 1983. This profit margin also was up slightly from the overall 11.1% recorded in fourth-quarter 1983.

The strength of the dollar overseas continued to bite into the bottom line. American Home Products, for instance, points out that despite overall unit growth, its foreign sales fell 6% expressed in dollars. Pfizer chief executive Edmund T. Pratt Jr. notes that Pfizer global sales rose 5% in local currencies but only 1% in dollars. E. Claiborne Robins Jr., chief executive of A. H. Robins, says that foreign exchange rates reduced that company's revenue $5.2 million. Currency translation cut corporate sales $21 million at SmithKline Beckman. Abbott Laboratories, Eli Lilly, Schering-Plough, G. D. Searle, and Squibb all explained that exchange rates hurt total sales figures.

But there also were signs that the depredations of the strong dollar are abating in some cases. Merck, for instance, says that although currency exchange continues to have an unfavorable effect on sales, the impact has moderated. At Warner-Lambert, where profit rose 18%, chairman Ward S. Hagan notes, "We attribute the first-quarter gain to the strong performance of our domestic operations and an improvement in foreign currency."

At the same time, nationwide efforts to trim health care spending have begun to affect pharmaceutical houses. Warner-Lambert, for one, explains that slower sales growth for its health technology products stems from reduced hospital admissions, shorter hospital stays, less surgery, and the new medicare reimbursement schedule, among other factors. Becton Dickinson, whose 23% earnings decline made it the worst performer in the group, registered a 1.3% revenue drop in its chief business segment, medical products. Again, the main reason cited was the slowdown in hospital admissions.

However, Abbott Labs, with a 17% income gain, says it was helped by the trend toward health care cost containment. "We've repeatedly said that the changes occurring in health care today represent opportunities for those companies that can provide the cost-effective products being demanded by the marketplace," comments Robert A. Schoellhorn, chief executive officer. "That's precisely what we're doing, and we're well on our way to another record year." Sales of the company's hospital and laboratory products rose 9% in the quarter, compared to a corporate revenue increase of 6%.

Record sales and earnings were reported by Abbott Labs, American Home Products, Eli Lilly, and Squibb. A. H. Robins reported record sales. The sharpest increase came at Searle, with earnings up 52% on a revenue gain of 41%. Searle, continuing to ride the aspartame rocket, also reported a slight improvement in its prescription drug segment.

Other companies were helped by sales of products not related to health care. Eli Lilly, for example, reported an 8% increase in both sales and earnings for the first quarter. Chairman Richard D. Wood gave much of the credit to strong sales gains by agricultural chemicals, particularly by the herbicides Treflan and Sonalan. At Sterling Drug, where overall net income rose 9% on a marginal revenue increase, sales climbed 6% in the company's chemicals and other products segment. And at Upjohn, where chemical product lines account for some 16% of total sales, chemical segment sales rose 14% from last year's first quarter.

At SmithKline Beckman, there was a solid sales increase for the company's bioanalytical systems operation. "This is a result of the rollout of new products and an upturn in both the bioresearch and biotechnology markets," said the company's chief executive officer, Henry Wendt. "We're also encouraged by incoming order patterns in this business."

The industry leaders ranked by sales were American Home Products, Bristol-Myers, Pfizer, Lilly, and Merck. The earnings leaders were American Home Products, Lilly, SmithKline Beckman, Pfizer, and Merck. And profitability leaders were SmithKline Beckman, Lilly, Merck, A. H. Robins, and Pfizer.

David Webber, New York

Pharmaceutical earnings rose 12% in the first quarter

	FIRST-QUARTER 1984					
	Sales	Earnings[a]	Change from 1983		Profit margin[b]	
Company	($ millions)		Sales	Earnings	1984	1983
Abbott Labs	$ 721.1	$ 87.7	6%	17%	12.2%	11.1%
American Home Products	1282.3	175.3	5	10	13.7	13.0
Avon Products	692.2	26.7	4	0	3.9	4.0
Becton Dickinson	285.6	13.6	3	−23	4.8	6.4
Bristol-Myers	1056.0	110.0	10	19	10.4	9.6
Eli Lilly	894.8	146.7	8	8	16.4	16.4
Merck	848.6	125.1	10	10	14.7	14.8
Pfizer	919.8	127.7	1	15	13.9	12.2
Revlon	564.0	24.5	2	3	4.3	4.3
A. H. Robins	156.3	22.4	14	43	14.4	11.4
Schering-Plough	486.5	53.3	3	−4	11.0	11.8
G. D. Searle	280.3	25.3	41	52	9.0	8.3
SmithKline Beckman	718.7	130.5	6	4	18.2	18.5
Squibb	428.9	36.9	6	11	8.6	8.2
Sterling Drug	447.0	30.2	1	9	6.8	6.3
Upjohn	563.0	65.0	16	43	11.5	9.4
Warner-Lambert	777.4	54.2	2	18	7.0	6.0

[a] Excludes significant extraordinary and nonrecurring items. [b] After-tax income as a percentage of sales.

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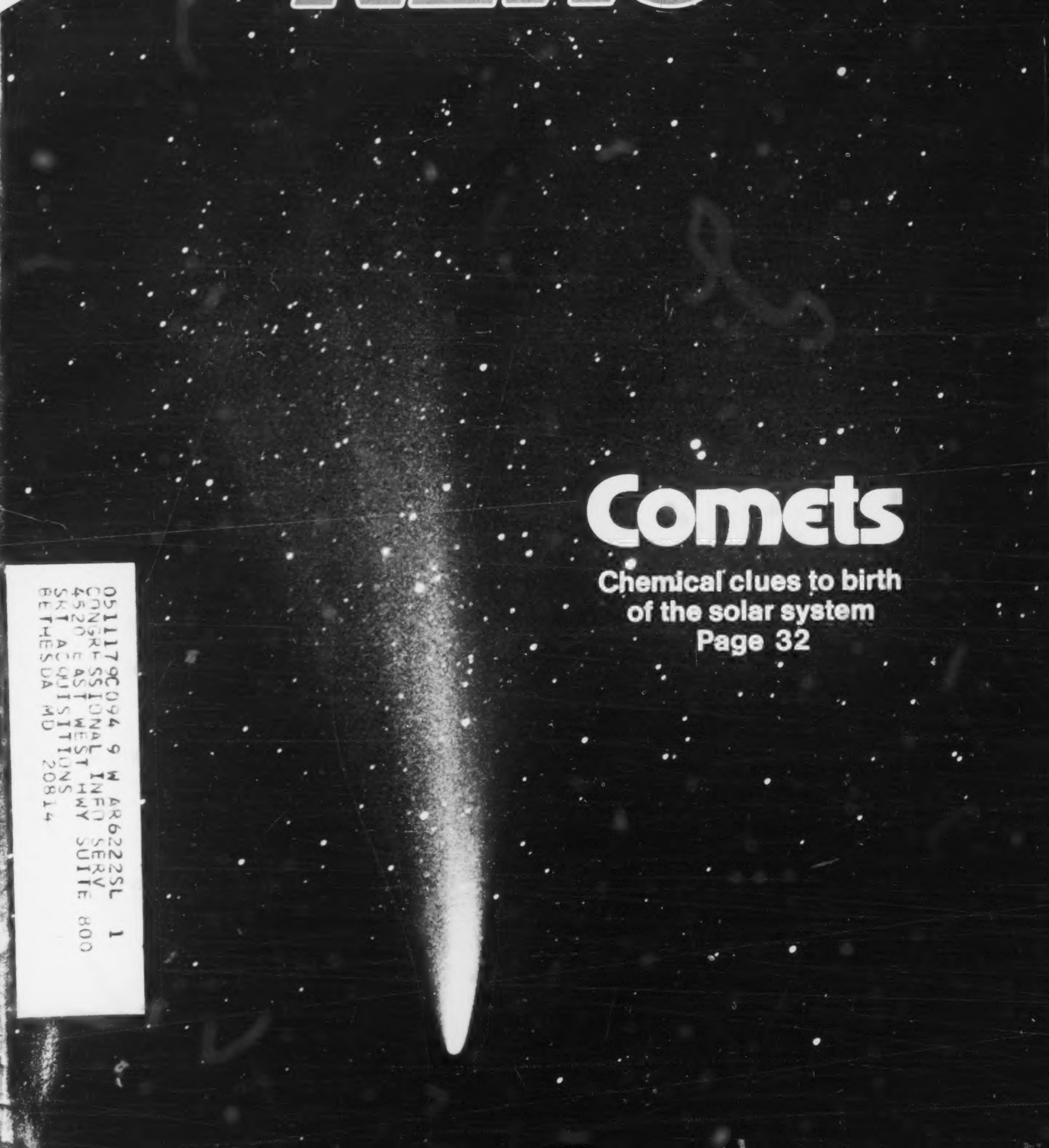

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- **Andrei Sakharov awarded honorary degrees by two universities in the U.S.** Page 6
- **FDA okays two oral drugs for diabetes for U.S. market.** Page 7
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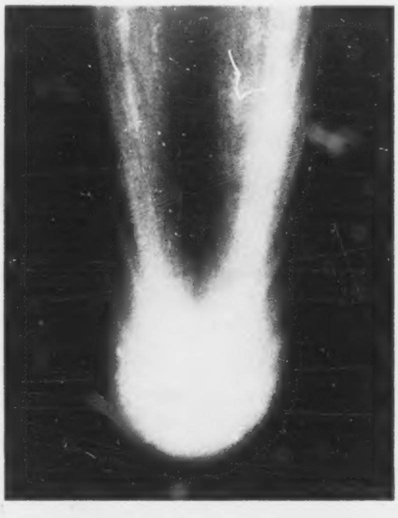


Special Report

Return of Halley's comet in 1986 will allow scientists to learn more about the chemistry of these mysterious objects. Page 32

Chemical Plant Capacity Use Continues Comeback

Capacity utilization rate for basic chemicals rose to 72%, for plastics to 81%; polymers at 81% again had highest use rate though down slightly from the third quarter

William J. Storck, C&EN New York
Bruce F. Greek, C&EN Houston

The U.S. chemical industry, after a long economic letdown, is getting itself back into shape. Sales and earnings are up strongly from a year ago, and profitability has increased from its recession low. And now rising demand—especially for organics—is boosting capacity utilization, a key measure of the industry's vitality and one used for planning capital improvements for years to come.

In the recent past, plant capacity use rates have been so low that there has been no need to build new plants. Even now, utilization rates continue low for the industry as a whole, on a historic basis, but C&EN's latest semiannual survey of capacity utilization shows considerable tightness in some basic chemical product lines.

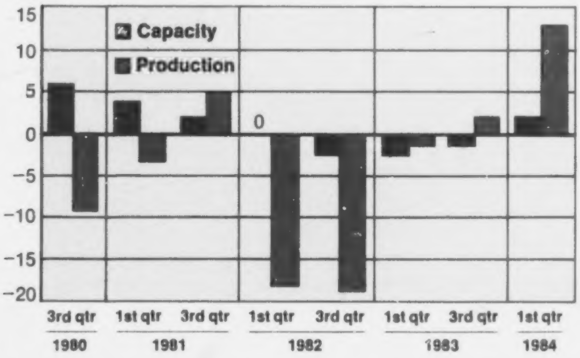
Specifically, the survey of 32 basic chemicals and 11 downstream polymers shows that in this year's first quarter capacity use for basic chemicals increased to an unweighted average of 72% from 68% in the third quarter of 1983. Within this group, organics capacity use climbed to 74% from 68% six months ago. Capacity use for inorganics increased to an average of 68% from 66%.

As in the previous survey, polymers again showed overall the highest capacity utilization rates, with plants running at about 81% of nameplate capacity. However, this was down slightly from 82% in the third quarter of 1983. Of this category, capacity use for major plastics rose to 81% from 79% six months ago, and use rates for fibers fell to 81% from 85%.

After factoring in various operating inefficiencies, including plant shutdowns for routine maintenance, effective capacity use rates for basic chemicals in-

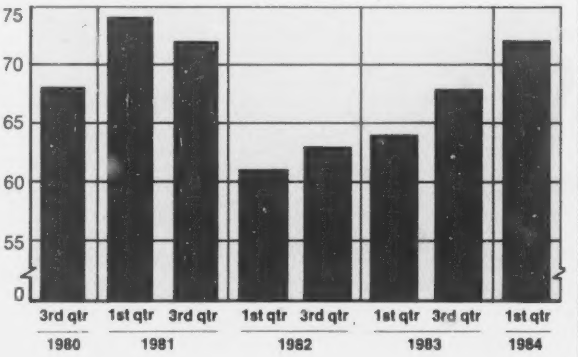
Chemical production has jumped and plant capacity is up moderately . . .

% year-to-year change for basic chemicals



. . . causing capacity use rates to continue climb from 1982 low

Basic chemicals' use of nameplate capacity, %



Sources: Industry and government data, C&EN estimates for 32 leading chemicals

Capacity utilization moved up moderately for basic chemicals in first-quarter 1984

Billions of lb unless otherwise noted[a]	First-quarter 1984			Third-quarter 1983			First-quarter 1983		
	Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use	
		Nameplate	Effective		Nameplate	Effective		Nameplate	Effective
Petrochemicals—olefins and aromatics[b]									
Ethylene	36.5	82%	91%	38.4	74%	82%	39.0	67%	74%
Propylene (chemical and polymer)	23.0	59	65	23.0	61	68	23.0	49	54
Butadiene[c]	4.5	51	56	4.5	58	64	4.5	37	41
Benzene (bg)	2.4	51	57	2.3	60	67	2.3	43	48
***p*-Xylene**	4.9	85	100	4.9	93	98	4.9	68	72
Petrochemicals—C_1 derivatives									
Ammonia (mt)[b]	17.8	88	91	18.7	64	67	18.7	71	75
Urea (mt)[b]	7.8	83	92	7.8	59	66	7.8	73	81
Methanol (bg)	1.9	60	67	1.8	63	70	1.7	56	62
Formaldehyde	9.2	56	59	9.2	56	59	9.2	55	58
Chlor-alkalies									
Chlorine (mt)[b]	13.4	72	76	14.5	70	74	14.4	67	71
Caustic soda (mt)[b]	14.3	68	72	15.5	66	70	15.4	66	69
Soda ash (mt)	11.0	77	81	10.7	81	85	10.7	74	78
Acids									
Sulfuric (mt)[b]	58.0	66	69	57.5	52	55	57.5	59	62
Phosphoric (P_2O_5, mt)[b,d]	12.5	82	86	12.5	66	69	12.5	71	75
Industrial gases									
Oxygen **Nitrogen** } (total, liquid, ttd)	39.4	61	75	40.0	64	78	37.0	64	78
Carbon dioxide (ttd)[e]	19.0	67	74	19.6	64	70	18.9	61	68
Mineral-based inorganics[b]									
Sulfur (total, mmt)	17.0	31	—	16.0	50	—	15.5	48	—
Potash (mt)	2.2	55	—	2.2	50	—	2.2	86	—
Phosphorus	0.55	67	70	0.55	67	71	0.55	65	69
Plastics intermediates									
Styrene	7.8	92	108	8.1	77	91	8.2	64	75
Vinyl chloride	10.0	54	61	9.3	79	87	10.1	65	72
Toluene diisocyanate	0.70	102	113	0.70	83	92	0.70	94	104
Fiber intermediates									
DMT-PTA[f]	7.6	82	97	7.6	80	94	7.3	64	75
Ethylene oxide	7.4	84	93	7.3	75	84	7.3	76	84
Cyclohexane[b]	3.4	62	66	3.4	52	55	3.4	31	33
Adhesives, coatings intermediates									
Phenol	3.3	85	94	3.3	83	92	3.6	64	71
Vinyl acetate	2.4	87	92	2.4	83	88	2.4	90	95
Pigments									
Carbon black	3.3	86	96	3.3	73	81	3.3	63	70
Titanium dioxide	0.90	84	98	0.91	86	100	1.0	60	71
Solvents									
Acetone	2.8	67	75	3.0	67	74	3.3	57	63
Ethanol (mg)	240.0	78	91	240.0	59	62	240.0	72	76
Methylene chloride	0.80	69	77	0.83	71	79	0.83	59	66
AVERAGE		**72%**	**82%**		**68%**	**76%**		**64%**	**70%**

[a] bg = billions of gallons, mt = millions of tons, tt = thousands of tons, ttd = thousands of tons per day, mmt = millions of metric tons, mg = millions of gallons. [b] Substantial capacity currently shut down. [c] Total extraction capacity, which runs about 25% more than basic production capacity. [d] Includes both wet-process and furnace-process capacity. [e] Excludes oilfield operations. [f] Dimethyl terephthalate and DMT equivalents of purified terephthalic acid. **Sources:** Industry and government sources, C&EN estimates

creased to 82% from 76%, but for polymers declined to 88% from 89%. Effective capacity is usually 5 to 15% lower than nameplate capacity.

During the recession most chemical companies worked hard to lower their break-even points on plant operations by upgrading and modernizing production lines and generally streamlining operations. As a result, the current increase in capacity utilization rates gives the companies a great amount of earnings leverage, with profits increasing faster than sales.

For instance, at Du Pont's annual meeting earlier this month, chairman Edward G. Jefferson said, "Effective cost reduction programs including process

Polymer capacity use is down slightly in first-quarter 1984

Billions of lb per year	First-quarter 1984 Capacity (nameplate)	First-quarter 1984 Capacity use Nameplate	First-quarter 1984 Capacity use Effective	Third-quarter 1983 Capacity (nameplate)	Third-quarter 1983 Capacity use Nameplate	Third-quarter 1983 Capacity use Effective	First-quarter 1983 Capacity (nameplate)	First-quarter 1983 Capacity use Nameplate	First-quarter 1983 Capacity use Effective
PLASTICS									
Polyethylene, low density	10.1	83%	88%	10.1	81%	86%	10.1	74%	79%
Polyvinyl chloride	8.3	78	92	8.9	71	83	8.9	55	64
Polyethylene, high density	6.8	87	91	6.3	94	99	6.3	85	89
Polypropylene	5.3	90	100	5.1	86	96	5.1	83	92
Polystyrene[a]	5.1	67	78	5.3	64	75	5.3	55	65
AVERAGE		**81%**	**90%**		**79%**	**88%**		**70%**	**78%**
SYNTHETIC FIBERS									
Filament yarn									
Polyester	1.5	84	90	1.6	88	93	1.6	83	88
Nylon	1.9	85	92	1.9	84	90	1.9	64	68
Olefin	1.1	63	67	1.1	71	75	1.0	48	51
Staple									
Polyester	2.8	82	87	2.7	89	95	2.7	75	80
Nylon	0.99	89	95	0.99	96	102	0.98	81	86
Acrylic	0.83	83	88	0.83	83	88	0.83	77	82
AVERAGE		**81%**	**86%**		**85%**	**91%**		**71%**	**76%**
OVERALL AVERAGE		**81%**	**88%**		**82%**	**89%**		**71%**	**77%**

a Between 5 and 10% of this capacity shut down. **Sources:** Industry sources, Society of the Plastics Industry, Textile Economics Bureau, C&EN estimates

modernization and productivity improvements contributed to earnings growth in 1983. These improvements give us excellent upside potential as capacity utilization rates continue to improve."

And Monsanto president and chief executive officer Richard J. Mahoney says that the asset management and restructuring programs of the past few years at his company brought significantly improved margins at higher production levels.

The industry's capacity situation may be much tighter than is indicated by the figures in the most recent survey. There is a large amount of capacity that remains shut down, but that is still included in C&EN's survey. This has happened for the simple reason that this shut-down capacity is still officially available for production if demand warrants it. For instance, at least 5% of U.S. nameplate capacity for ethylene remains closed from the recession, but it is as yet unknown how much of it may never again be restarted. Other chemicals in a similar situation include propylene, butadiene, benzene, ammonia, urea, chlorine, caustic soda, sulfuric acid, styrene, and methanol.

In methanol, Celanese's Clear Lake, Tex., plant has been closed since January and probably will be replaced at some time in the future by imports from Canada and Saudi Arabia. However, as of now, Celanese still lists the plant as operable and has not announced a permanent shutdown, so the plant is included in the survey.

The capacity utilization rate for basic chemicals of 72% for the first quarter is very close to the Federal Reserve Board's seasonally adjusted theoretical capacity utilization rate for chemicals and allied products of 71.4% in the first quarter, down from 72.1% in the fourth quarter of 1983 and the same as the 71.4% registered in the third quarter.

C&EN figures are closer to reality, however, as more companies announce permanent shutdowns of their plants and as more capacity that was closed temporarily is brought back on stream to supply increased demand. Oddly enough, the capacity that has been put back on line just about equals capacity that was closed down permanently in the first quarter. Thus, total capacity for the 32 basic chemicals in the survey has remained fairly constant since the third quarter.

Of the 32 products on the basic chemical list, 17 of them have seen changes in capacity since the third quarter. Of these, capacity has declined for 10 and increased for seven.

The largest decreases were 7.7% and 7.6% for caustic soda and chlorine, respectively, and 6.7% for acetone. The largest increase was a 7.5% jump in vinyl chloride capacity, fueled by increased demand for downstream polymer polyvinyl chloride. Other increases were 6.3% for sulfur, 5.6% for methanol, and 4.3% for benzene.

The survey also shows that, unfortunately, capacity use for basic olefins and aromatics, which have a large effect on industry profits, dropped to 66% in the first quarter from 69% in third-quarter 1983, in spite of some capacity trimming. Only ethylene showed an increase in capacity use during the period, rising to 82% of nameplate capacity in the first quarter from 74% six months earlier. Capacity use for the other four chemicals—propylene, butadiene, benzene, and *p*-xylene—all declined, with the biggest drops for butadiene, to 51% from 58%, and for benzene, to 51% from 60%.

C&EN capacity use indicator: the ground rules

Capacity use at chemical plants is difficult to measure and requires certain assumptions. These bring some order to the maze of variables affecting this critical indicator of the industry's health.

With the help of industry and government sources, C&EN measures capacity use as a percentage of both nameplate and effective maximums. Nameplate capacity is the official design capacity of plants. Effective capacity is the practical maximum after reductions for unplanned maintenance, corrosion problems, changes in product mix, and other influences. Although engineering companies and industry statistics groups try to make nameplate capacity data as real as possible, practical problems almost always reduce effective maximums to 85 to 95% of the official totals. For short periods, plants can run at more than 100% of effective top capacity, but such a rate doesn't last more than a few months.

Capacity use is given over as much of a calendar quarter as production data permit, with no seasonal adjustment. The figures are for plants actually operable. At present, some products such as ethylene, ethanol, chlorine, polystyrene, ammonia, and urea have plants temporarily shut down because of weak markets. These plants still are included in capacity totals. The totals exclude new plants just starting up and old plants out of operation for long periods because of accidents. As much as possible, capacity figures stay current with expansions.

Capacity data don't take into account other temporary fluctuations for fuel and electric power interruptions, equipment failure, and feedstock scarcity or substitution. The feedstock variables, for example, have been important in the past few years in ethylene production, altering maximum output for several coproducts such as propylene, butadiene, and benzene.

Products in C&EN's capacity use survey are the same as those in the Key Chemicals and Key Polymers series. These are the core products of the industry, the building blocks leading to downstream production of thousands of more specialized products.

On the other hand, capacity use for C1 petrochemicals showed a healthy increase to 72% from 61% as demand for agricultural chemicals picked up. This pickup also is evident in a gain to 88% capacity use for ammonia from 64%, and to 83% for urea from 59%. Of the other two chemicals in the C1 category, methanol's capacity use dropped slightly to 60% from 63%, and formaldehyde's remained a constant 56%.

The highest average capacity utilization for any group of the basic chemicals surveyed was for adhesives and coatings intermediates, which increased to 86% in the first quarter from 83% six months before. Within the group, capacity use for vinyl acetate increased to 87% and phenol to 85%, both from 83% in third-quarter 1983.

Next highest was for the pigments group, average capacity utilization for which rose to 85% from 80%. In this group, carbon black's capacity use increased to 86% from 73%, but titanium dioxide's fell to 84% from 86%.

Plastic intermediates also posted a relatively high capacity utilization, increasing to 83% of nameplate capacity from 80% in last year's third quarter. In this group, styrene capacity use rose to 92% from 77%, vinyl chloride's fell to 54% from 79% as additional capacity was brought on stream, and toluene diisocyanate's increased to 102% from 83%, indicating that TDI makers continue their traditional practice of understating production capacity possibly as much as 20%.

Other groups with above-average capacity utilization include the fiber intermediates, which increased to 76% from 69%, and the big acids, which rose to 74% from 59%, largely on the strength of phosphoric acid.

Groups within those chemicals surveyed whose capacity use was about average include, in addition to the C1 petrochemicals, the chlor-alkalies, which stayed at 72%, and solvents, which increased to 71% from 66%.

Those below the average, in addition to the olefins and aromatics, included industrial gases, whose capacity use remained at 64%, and the mineral-based inorganics, whose capacity utilization dropped to 51% from 56% on an increase in sulfur capacity that was not made up by an increase in production. Capacity use for sulfur fell to 31% from 50% during the period.

Despite the one percentage point decline in average capacity utilization for downstream polymers, they remained the bright spot for chemical producers. The major plastics increased capacity use to an average of 81% from 79% in the surveyed period. All of the major plastics, with the exception of high-density polyethylene, had increases in capacity utilization. That for low-density polyethylene increased to 83% from 81%, and that for PVC rose to 78% from 71%, largely because of declining capacity.

Polypropylene was the stellar plastic with capacity utilization up to 90% from 86%, and polystyrene the laggard with an increase to 67% from 64%. Only high-density polyethylene showed a decline, with utilization rates dropping to a still-above-average 87% from 94%.

While most plastics' use rates were rising, those for fibers were dropping. Capacity utilization for the major synthetic fibers fell to 81% in the first quarter from 85% in last year's third quarter.

Among the fibers, by construction, filament yarn fared worst, with capacity utilization falling to 77% from 81%. This low use rate was strongly influenced by a drop in olefins to 63% from 71%. Staple types fared much better, but still dropped to 85% from 89%. Only nylon filament showed an increase in use rates, rising to 85% in the first quarter from 84% in last year's third quarter. Acrylic capacity use remained at 83%. □

Chemical Stocks Follow Market Down

Index of chemical stocks, currently below level of a year ago, is doing only slightly better than overall stock market

David Webber, C&EN New York

It was just about a year ago that chemical stocks began charging ahead of the rest of the stock market. Riding a wave of optimistic earnings forecasts by analysts, prices of chemical shares, as measured by C&EN's chemical stock index, stood in September at 133% of their value at the beginning of 1983. The Dow Jones Industrial Average, by comparison, had risen only to 116% of its January 1983 level.

Those glory days are just fond memories now. When the stock market crested in mid-January, having run up against fears of the big federal budget deficit and higher interest rates, the chemical stock group corrected itself even more severely. Between the middle of January and the middle of February, for example, the Dow Jones average plunged 9.5%. During the same period, the chemical stock index dived a little more than 13%.

It was an abrupt return to Earth for the high-flying chemical stocks. Since February, the C&EN index has risen some 7%, but at the middle of May was still lower than its level in May 1983.

The C&EN index—based on the stock prices of Allied, American Cyanamid, Celanese, Dow Chemical, W. R. Grace, Monsanto, and Union Carbide—is not only lower than it was last year at this time, but a broader sample consisting of 29 major chemical company stocks shows the same trend. In the larger group, the price of a share of common stock is lower in 21 cases than it was in May 1983.

Of the major chemical companies, the best stock issue over the past 12-month period has been Celanese. In a year of overall recovery for the fibers and chemicals company, which increased its earnings 633% between the first quarter of 1983 and the first quarter of 1984, the price of a share of common stock rose nearly 24% to reach $73 recently. The only other chemical stock to grow to an extent anywhere near that over the past year has been Morton Thiokol, which has risen from $62½ last May to $76 recently, an increase of 22%.

The only other winners in the year-to-year comparison are Monsanto, whose common stock price rose 13% during the period to close at $92½ recently; Allied, whose stock price rose 6.2% over the span to $51¼; Du Pont, up 5.8% to $48; Ethyl, up 4.5% to $20⅜; and American Cyanamid, up 1.3% to $49⅞.

The worst performers in the year-to-year comparison of common stock prices are Stauffer Chemical—whose earnings have been hit hard over the past several quarters by first the slump in the corn herbicide market and then its slowness to recover—down 24% over the period to close recently at $18; First Mississippi, down 22% to $9¼; Union Carbide, whose earnings recovery has been lagging much of the rest of the chemical industry, down 19% to $55⅝; Hercules, down 18% to $31⅜; and W. R. Grace, down 17% to $39.

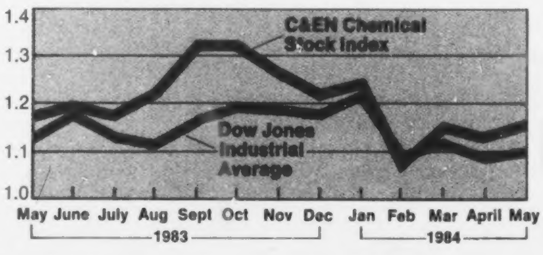
The extent of this return to averageness on the part of chemical

Chemical stocks have fallen more than other industrial indexes. . .

	May 18, 1984	May 20, 1983	% change
C&EN Chemical Stock Index[a]	250	254	−1.6%
Dow Jones Industrial Average	1157.14	1190.02	−2.8
New York Stock Exchange Composite	91.23	93.71	−2.6
New York Stock Exchange Industrials	107.17	108.33	−1.1
American Stock Exchange Index	209.21	224.81	−6.9
Over-the-Counter Composite	250.57	303.56	−17.5
Over-the-Counter Industrials	282.45	366.38	−22.9
Standard & Poor's 500	158.49	162.14	−2.3
Standard & Poor's 400 Industrials	179.51	181.78	−1.2

[a] C&EN index based on stock prices for Allied, American Cyanamid, Celanese, Dow Chemical, W. R. Grace, Monsanto, and Union Carbide.

. . . and are no longer outperforming the stock market by very much



Note: Both indexes reindexed to January 1983 = 1.00 to make comparable. Based on mid-month stock data.

Many chemical stocks are lower than a year ago

	Stock price				Per cent change			Price/earnings ratio May 18	Annual indicated dividend	Dividend yield, % of price
	May 18, 1984	May 20, 1983	12-month low	12-month high	From one year ago	From low	From high			
Air Products	$42¾	$42¾	$36½	$51	0.0%	17.1%	−16.2%	10	$1.00	2.3%
Allied	51¼	48¼	47¼	58⅛	6.2	8.5	−11.8	9	2.40	4.7
American Cyanamid	49⅞	49¼	42⅛	59	1.3	18.4	−15.5	12	1.90	3.8
Celanese	73⅛	59⅛	58⅛	79¾	23.5	25.6	−8.5	8	4.00	5.5
Chemed	33¼	35½	27¾	40	−6.3	19.8	−16.9	14	1.48	4.5
Dow Chemical	30¾	32¼	27⅛	38⅜	−4.7	13.4	−19.9	17	1.80	5.9
Du Pont	48	45⅜	42⅜	55	5.8	13.3	−12.7	9	2.80	5.8
Essex Chemical	22⅞	26⅞	17	28½	−14.9	34.6	−19.7	20	0.80	3.5
Ethyl	20⅜	19½	19	29¾	4.5	7.2	−31.5	8	0.85	4.2
First Mississippi	9¼	11⅞	8¾	15½	−22.1	5.7	−40.3	16	0.24	2.6
Freeport-McMoRan	20½	23⅛	18⅝	27⅜	−11.4	9.8	−25.1	16	0.60	2.9
W. R. Grace	39	47⅛	38⅜	50⅜	−17.2	1.6	−22.6	11	2.80	7.2
Hercules	31⅜	38⅜	28¾	43⅛	−18.2	9.1	−27.2	9	1.44	4.6
International Flavors	26	27½	23⅝	35⅜	−5.5	9.8	−27.3	14	1.08	4.2
International Minerals	35¾	42⅞	36	49	−16.6	−0.7	−27.0	10	2.60	7.3
Loctite	32¼	38⅜	32	46½	−16.0	0.8	−30.6	13	0.68	2.1
Lubrizol	19⅝	20⅞	18¼	27⅞	−5.7	7.8	−29.4	12	1.08	5.5
Monsanto	92½	81⅝	80	116⅜	13.3	15.6	−20.5	9	4.60	5.0
Morton Thiokol	76	62½	60	84½	21.6	26.7	−10.1	12	1.76	2.3
Nalco Chemical	24⅜	29¼	23⅜	37	−16.7	4.3	−34.1	13	1.20	4.9
National Distillers	27¾	28⅝	24¼	31	−3.2	14.4	−10.5	13	2.20	7.9
Olin	28⅛	30¼	25⅛	34	−7.0	11.9	−17.3	9	1.32	4.7
Pennwalt	35¼	40½	33¼	45¾	−13.0	6.0	−23.0	10	2.20	6.2
PPG Industries[a]	27¾	64⅛	27⅛	38	−56.7	2.3	−27.0	7	1.44	5.2
Reichhold Chemicals	27¼	28	25⅛	38⅞	−2.7	8.5	−29.9	9	0.60	2.2
Rohm & Haas	60½	115½	49½	81	−47.6	22.2	−25.3	10	1.60	2.6
Stauffer Chemical	18	23⅝	17½	31¾	−24.0	2.9	−43.3	—	1.44	8.0
Union Carbide	55⅝	68⅝	52	73⅞	−18.9	7.1	−24.6	29	3.40	6.1
Witco Chemical	32	39¼	26⅛	39½	−18.5	22.5	−19.0	8	1.32	4.1

[a] Adjusted for stock split.

stocks in general is readily apparent in a comparison of how C&EN's chemical stock index stood relative to other major stock market measures in January, when the stock market correction was beginning, and now. For instance, at that point, the chemical stock index had risen almost 22% over the previous 12 months, an increase above the Dow Jones Industrial Average, the New York Stock Exchange Composite, the New York Stock Exchange Industrials, the Over-the-Counter indexes, and the Standard & Poor's indexes. Only the American Stock Exchange index, up 24%, had done better.

Now, the chemical stock index's 12-month performance fits right in with that of most of the rest of the stock market. Although the C&EN measure has declined less over the past year than the Dow Jones average, the New York Stock Exchange Composite index, and the Standard & Poor's 500, it has done worse than the New York Stock Exchange Industrials index and the Standard & Poor's 400 Industrials.

Over the same period, the American Stock Exchange index has declined 6.9%, the Over-the-Counter Composite index has declined about 18%, and the Over-the-Counter Industrials has declined 23%.

Another sign of the chemical industry's stock market problems is that recent common stock prices tend to be closer to the low end of the share's 12-month price range than to the high end. In the 29-stock group, in fact, only four companies' shares are selling at prices above the midpoint of their one-year range. Those firms are Celanese, Essex Chemical, Morton Thiokol, and National Distillers.

Meanwhile, a number of companies are trading close to the bottom of their 12-month price range. Most noticeable are the specialty chemical producers: Loctite, at $32¼ recently, barely above its 12-month low of $32; Lubrizol, at $19⅝, near its low of $18¼; and Nalco Chemical, at $24⅜, compared to a low of $23⅜.

The chances for a chemical stock rally depend, on the one hand, on the ability of companies to make real their mostly optimistic earnings forecasts for the year, and, on the other hand, the unpredictable movement of interest rates and inflation. The huge federal budget deficit is still sparking predictions of woe from many quarters. In this climate of uncertainty, the stock market, which fell more than 23 points between May 14 and 18, shows little sign of a general rally soon. □

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CHEMICAL & ENGINEERING NEWS

PROCESS CONTROL

Faster, smaller, more integrated sensors
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CHEMICAL & ENGINEERING NEWS

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News of the Week

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- **British court upholds injunction by Monsanto to prevent Stauffer from selling its glyphosate-based herbicide in the U.K.** Page 5
- **Once-a-day injectable cephalosporin antibiotic, introduced by Smith Kline & French, has FDA approval.** Page 5

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Business

Overall profitability of U.S. chemical companies in 1983 was almost the same as in 1982; likewise, smaller, more specialized firms did better than the larger commodity makers. **Page 17**

Many specialty chemicals will continue to outperform commodities but competition will intensify, analyst predicts. **Page 20**

International Business

Resource-rich province of Alberta welcomes specialty chemicals firms to take advantage of its petrochemical base. **Page 24**

Government

Office of Science & Technology Policy report on assessing cancer risks of chemicals is general guide for all agencies. **Page 32**

Review of EPA's administration policies cites politicization, lack of a permanent mission, fragmented R&D setup. **Page 33**

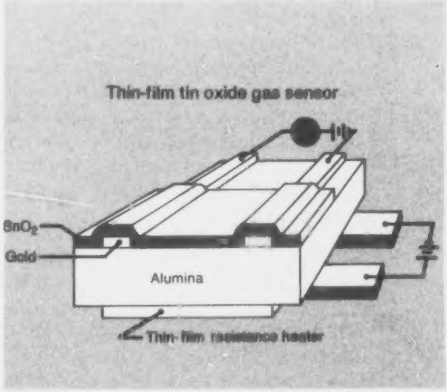
Parsons Award

Franklin Long, professor emeritus at Cornell University and long-time advocate of arms control, receives ACS's Charles Lathrop Parsons Award for outstanding public service. **Page 34**

Science

Study of intramolecular electron transfer reactions in solutions reveals evidence of existence of inverted region. **Page 42**

Synthetic binuclear copper complex that binds molecular oxygen as peroxide is prepared, characterized by SUNY scientists. **Page 44**



News Focus

The next revolution in process control will be development of smaller, faster sensors. Page 7

Chemical Profitability Changed Little in 1983

Average profit margin for 36 chemical companies surveyed remained at 4.3%; specialty chemical firms again led rankings

William J. Storck, C&EN New York

Overall profitability of U.S. chemical firms changed little last year from 1982, based on data gleaned from annual reports of the 36 largest chemical companies. (For the purpose of this C&EN survey, chemical companies are defined as having 40% or more of total sales in chemicals, with chemicals as the single largest product category.)

Analysis of these data shows that average profit margin for the 36 companies remained at 4.3%, return on investment stayed at 3.2%, return on assets dropped to 4.2% from 4.3% in 1982, and return on year-end stockholders' equity remained at 8.8%.

Even though several individual companies improved in these profitability measures during the year—and conversely, others weakened—the lack of change in the group as a whole probably reflects that, economically, both years had a poor half: the second half of 1982 and the first half of 1983. With that similarity, the increasing profits and profitability of second-half 1983 still could not overcome the weak performance of these measures in the first half of the year.

For the year, gains in earnings were pretty well matched by gains in sales, total assets, stockholders' equity, and return on investment (current assets plus gross plant).

The top companies in overall profitability

1. Lawter International
2. International Flavors
3. Nalco Chemical
4. Great Lakes Chemical
5. Chemed
6. Petrolite
7. Lubrizol
8. Rohm & Haas
9. Loctite
10. Ethyl

As was the case in 1982, smaller, more specialized firms dominated the profitability rankings for 1983, although their dominance was not so complete as it has been in the past. In 1983, some of the larger firms, though still heavily involved in specialty chemicals, also ranked high.

Profit margins at U.S. chemical companies held at 4.3% in 1983

Rank 1983	Rank 1982		Profit margin[a] 1983	Profit margin[a] 1982
1	2	**Lawter International**	15.9%	12.5%
2	1	**International Flavors**	14.8	14.1
3	3	**Freeport-McMoRan**	11.5	11.1
4	5	**Nalco Chemical**	10.8	10.0
5	6	**Great Lakes Chemical**	10.5	9.7
6	15	**Lubrizol**	8.1	5.9
7	10	**Loctite**	7.9	7.3
8	6	**Petrolite**	7.7	9.7
9	22	**Rohm & Haas**	7.5	4.1
10	4	**First Mississippi**	6.9	10.4
11	11	**Air Products**	6.7	6.7
12	16	**Ethyl**	6.6	5.7
13	11	**Chemed**	6.4	6.7
14	19	**PPG Industries**	6.3	4.7
15	17	**Monsanto**	6.2	5.4
16	24	**Hercules**	5.7	3.7
17	9	**International Minerals**	5.4	7.5
18	14	**Liquid Air**	5.2	6.1
18	13	**Morton Thiokol**	5.2	6.2
20	23	**American Cyanamid**	4.7	3.8
21	28	**Pennwalt**	4.6	2.6
22	32	**Witco Chemical**	3.8	2.3
23	27	**Olin**	3.7	2.9
24	35	**Celanese**	3.6	0.2
25	28	**H. B. Fuller**	3.2	2.6
26	30	**Stepan Chemical**	3.0	2.5
27	19	**Essex Chemical**	2.9	4.7
28	25	**Union Carbide**	2.8	3.4
29	31	**Crompton & Knowles**	2.7	2.4
29	34	**Reichhold Chemicals**	2.7	0.9
31	21	**National Distillers**	2.6	4.3
31	18	**W. R. Grace**	2.6	5.2
33	26	**Dow Chemical**	2.5	3.2
33	33	**Williams Cos.**	2.5	1.8
35	—	**Beker Industries**	0.4	def
—	8	**Stauffer Chemical**[b]	def	8.2
		AVERAGE	**4.3%**	**4.3%**

a After-tax income, excluding extraordinary and nonrecurring items as a percentage of sales. b Stauffer's results for fiscal year ended Sept. 30, 1983, are being compared with results for calender year 1982. def = deficit.

Return on investment stayed flat at 3.2% last year

Rank 1983	Rank 1982		Return on investment[a] 1983	Return on investment[a] 1982
1	2	**Lawter International**	16.1%	13.2%
2	3	**International Flavors**	12.7	12.4
3	1	**Chemed**	12.1	14.0
4	4	**Nalco Chemical**	11.5	11.1
5	7	**Great Lakes Chemical**	8.5	6.7
6	6	**Loctite**	8.2	7.7
7	5	**Petrolite**	7.7	11.0
8	8	**Lubrizol**	7.5	6.0
9	10	**Ethyl**	6.8	5.5
10	10	**Morton Thiokol**	6.7	5.5
11	22	**Rohm & Haas**	6.4	3.7
12	26	**Hercules**	5.8	3.3
13	19	**H. B. Fuller**	5.6	3.8
14	23	**Witco Chemical**	5.4	3.5
15	23	**PPG Industries**	4.7	3.5
16	18	**Freeport-McMoRan**	4.6	3.9
16	19	**Crompton & Knowles**	4.6	3.8
18	33	**Reichhold Chemicals**	4.2	1.5
19	19	**Monsanto**	4.1	3.8
20	26	**American Cyanamid**	4.0	3.3
21	29	**Pennwalt**	3.9	2.4
22	23	**Air Products**	3.5	3.5
23	9	**First Mississippi**	3.4	5.8
23	17	**Liquid Air**	3.4	4.0
25	28	**Stepan Chemical**	3.3	2.8
26	13	**International Minerals**	3.1	4.9
26	16	**National Distillers**	3.1	4.5
28	15	**Essex Chemical**	2.9	4.6
29	32	**Olin**	2.6	2.1
29	12	**W. R. Grace**	2.6	5.4
31	35	**Celanese**	2.5	0.1
32	31	**Union Carbide**	1.8	2.2
33	30	**Dow Chemical**	1.7	2.3
34	34	**Williams Cos.**	1.1	1.0
35	—	**Beker Industries**	0.3	def
—	14	**Stauffer Chemical**[b]	def	4.7
		AVERAGE	**3.2%**	**3.2%**

a Earnings excluding extraordinary and nonrecurring items as a percentage of current assets plus gross plant. b Stauffer's results for fiscal year ended Sept. 30, 1983, are being compared with results for calendar year 1982. **def** = deficit.

Individually, the most profitable chemical company in the U.S. last year, with a first-place ranking in all four profitability measures, was the smallest company in the group—Lawter International, a Chicago area-based maker of pigments and compounds primarily for printing inks and paints, with 1983 sales of $90 million.

Other companies among those with the highest overall profitability rankings also tended to be smaller, quite specialized companies—International Flavors & Fragrances, Nalco Chemical, Great Lakes Chemical, Chemed, and Petrolite. It is not until seventh place that what could be called a medium-sized company—Lubrizol—can be found. Ranking eighth is Rohm & Haas, a larger, more diversified firm, but one still heavily involved in high-value-added products. Loctite ranks ninth, followed by Ethyl, which, like Rohm & Haas, is diversified but heavily involved in specialties. Overall profitability rankings are figured simply by adding the relative rankings in each of the four

Return on assets declined slightly to 4.3%

Rank 1983	Rank 1982		Return on assets[a] 1983	Return on assets[a] 1982
1	1	**Lawter International**	18.9%	15.6%
2	2	**International Flavors**	14.9	14.6
3	4	**Nalco Chemical**	14.5	13.9
4	2	**Petrolite**	10.6	14.6
5	6	**Great Lakes Chemical**	10.5	8.1
6	8	**Lubrizol**	9.5	7.4
7	16	**Rohm & Haas**	9.4	5.5
8	5	**Chemed**	8.8	10.1
9	7	**Loctite**	8.0	7.9
10	12	**Ethyl**	7.6	6.1
11	24	**Witco Chemical**	7.1	4.5
12	21	**Hercules**	6.9	4.7
13	9	**Morton Thiokol**	6.8	6.5
14	21	**PPG Industries**	6.4	4.7
14	19	**Freeport-McMoRan**	6.4	5.0
16	26	**H. B. Fuller**	6.1	4.2
17	15	**Monsanto**	6.0	5.6
18	25	**American Cyanamid**	5.4	4.4
19	33	**Reichhold Chemicals**	5.2	1.9
20	30	**Pennwalt**	5.1	3.2
21	27	**Crompton & Knowles**	5.0	4.0
22	20	**Air Products**	4.9	4.8
23	18	**Liquid Air**	4.5	5.1
24	28	**Stepan Chemical**	4.3	3.3
25	35	**Celanese**	4.1	0.2
25	11	**International Minerals**	4.1	6.3
27	28	**Olin**	3.9	3.3
28	14	**First Mississippi**	3.7	5.9
29	23	**National Distillers**	3.4	4.6
29	17	**Essex Chemical**	3.4	5.2
31	9	**W. R. Grace**	3.2	6.5
32	31	**Union Carbide**	2.4	2.9
33	31	**Dow Chemical**	2.3	2.9
34	34	**Williams Cos.**	1.2	1.3
35	—	**Beker Industries**	0.3	def
—	12	**Stauffer Chemical**[b]	def	6.1
		AVERAGE	**4.2%**	**4.3%**

a Earnings excluding extraordinary and nonrecurring items as a percentage of total assets. b Stauffer's results for fiscal year ended Sept. 30, 1983, are being compared with results for calendar year 1982. **def** = deficit.

Return on stockholders' equity remains at 8.8%

Rank			Return on equity[a]	
1983	1982		1983	1982
1	3	**Lawter International**	25.6%	19.1%
2	1	**Chemed**	21.5	33.5
3	3	**Nalco Chemical**	20.3	19.1
4	5	**International Flavors**	19.9	18.8
5	9	**Great Lakes Chemical**	16.8	13.6
6	23	**Rohm & Haas**	15.6	9.3
7	19	**Witco Chemical**	15.4	10.0
8	17	**H. B. Fuller**	15.0	10.5
9	2	**Petrolite**	14.7	20.8
10	11	**Morton Thiokol**	14.3	12.6
11	18	**Lubrizol**	13.7	10.3
12	14	**Ethyl**	13.6	11.5
13	10	**Loctite**	12.8	12.8
14	24	**PPG Industries**	12.6	9.1
15	16	**Freeport-McMoRan**	12.3	11.3
16	25	**Hercules**	11.7	8.6
17	6	**Essex Chemical**	11.6	18.0
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19	22	**Stepan Chemical**	10.8	9.6
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23	35	**Celanese**	10.2	0.4
24	30	**Pennwalt**	9.4	6.7
25	28	**Crompton & Knowles**	9.2	7.4
26	7	**First Mississippi**	9.1	16.0
27	20	**Liquid Air**	8.5	9.8
27	31	**Olin**	8.5	6.6
29	13	**International Minerals**	7.9	12.1
30	8	**W. R. Grace**	7.3	14.5
31	27	**National Distillers**	6.9	7.9
32	29	**Dow Chemical**	5.4	6.8
33	32	**Union Carbide**	5.1	6.0
34	34	**Williams Cos.**	4.6	2.9
35	—	**Beker Industries**	0.9	def
—	12	**Stauffer Chemical**[b]	def	12.3
		AVERAGE	8.8%	8.8%

a Earnings excluding extraordinary and nonrecurring items as a percentage of year-end stockholders' equity. b Stauffer's results for fiscal year ended Sept. 30, 1983, are being compared with results from calendar year 1982. def = deficit.

categories of profitability measurement.

Within the rankings of the four profitability measures, considerable movement occurred between 1982 and 1983. In the profit margin listing, for example, only three of the companies retained the same ranking in 1983 as in 1982. Of the others, 20 moved up in rank, and 13 declined. For the return-on-investment ranking, six retained the same rank, 19 advanced, and 11 moved down. In the ranking of return on assets, three companies remained at the same rank, 18 improved, and 15 declined. And for return on equity, two retained the same ranking, 21 moved up, and 13 fell back.

Lawter, the first-place company in all categories, ranked first in 1982 only in return on assets, but moved up from second in both profit margin and return on investment and from third in return on equity.

But there was much greater movement for other firms. Rohm & Haas probably improved the most overall, jumping to ninth place in profit margin, with 7.5%, from 22nd place in 1982 with 4.1%. Its 6.4% return on investment raised it to 11th rank in 1983 from 22nd in 1982 with 3.7%; a 9.4% return on assets brought it to seventh place from 16th the year before with 5.5%; and a 15.6% return on equity boosted it to sixth place from 23rd in 1982 with 9.3%.

Other companies also posted strong improvements in some but not all categories. For instance, Reichhold Chemicals, long an industry laggard, moved up five places to 29th in profit margin in 1983, but in return on assets it moved up 14 places to 19th. And in both return on investment and return on equity it increased its rank 15 spots to 18th place in both cases. Thus, Reichhold in 1983, far from being a trailer, has moved solidly into the middle of the pack.

Others showing healthy increases in at least some categories include Hercules, Witco Chemical, Celanese, Lubrizol, and H. B. Fuller.

It was not all forward movement in the rankings, however. In the worst such case, Stauffer Chemical, with a deficit in 1983, weakened its profitability position, effectively taking it out of the rankings in which the year before it ranked eighth in profit margin, 12th in both return on assets and return on equity, and 14th in return on investment.

Another large decline struck W. R. Grace, which fell 13 places to 31st in profit margin, 17 places to 29th in return on investment, 22 spots to 31st in return on assets, and 22 places to 30th in return on equity.

Other large drops in ranking in the four profitability measures were registered by the fertilizer and mineral companies—First Mississippi and International Minerals & Chemicals—and at National Distillers, Essex Chemical, and Liquid Air.

Because data for this survey derive from annual reports, a few companies with fiscal years ending in the second or third quarter of last year, such as Air Products, International Minerals, and Loctite, were not able to report the full effect of the recovery in the latter part of the year in their annual figures. Thus, their results might have been higher if they had been reported for the calendar year.

Whereas the chemical industry's profitability went virtually nowhere last year, it looks as if 1984 will be a different story. The momentum that started in the latter part of 1983 has continued, and, barring catastrophe, profitability will be up significantly this year. In C&EN's latest survey of earnings of 30 major chemical companies (C&EN, May 14, page 10), profit margins—the one profitability measure that can be gauged quarterly—rose to 5.7% in the first quarter from just 3.8% in first-quarter 1983. □

Specialty chemicals: mixed bag for growth

The specialty chemical business will continue to be more attractive than commodity chemicals. In general, profits will be higher, sales growth will be faster, and specialties will be less cyclical than commodities.

That's part of the analysis of the U.S. specialty chemical industry that Frode Nordhoy, president of Strategic Analysis Inc., Reading, Pa., brought to Toronto, where he presented it as a guide for his Canadian counterparts at a meeting on specialty chemicals sponsored by the Corpus Chemical Group.

What Nordhoy told them was that many specialties will continue to outperform other segments of the chemical industry in both sales growth and profitability. Specialties will offer many opportunities to companies already in the business as well as to companies trying to diversify into them.

However, some segments of the specialty chemical business will be much more attractive than others, he says. Despite the glamorous-sounding overtones of specialties, some segments of the business already are mature; others are aging.

In addition, competition will become more intense in the marketplace. And rapidly changing technologies will present some companies with insurmountable problems.

Nordhoy pegs last year's U.S. market for 30 identifiable classifications of specialty chemicals at $40.6 billion. But the business, he points out, is very fragmented. Agricultural chemicals, the largest individual segment with 1983 sales of $5.5 billion, account for only about 14% of the total. The top five segments, which in addition to agricultural chemicals include oil field chemicals, industrial coatings, specialty lubricants, and industrial and institutional cleaners, account for almost half of total sales. On the bottom end, half (15) of the segments have less than a 2% share of the total. That, says Nordhoy, is fragmentation.

Despite this fragmentation, specialty chemicals are big business. Almost half of Nordhoy's 30 segments had 1983 sales of $1 billion or more.

For the remainder of the decade, U.S. specialty chemical sales will increase faster than gross national product, as they historically have. Assuming that GNP will maintain an average 3- to 4%-per-year growth pace, Nordhoy says that total U.S. specialty chemical sales will increase an average 5% annually. That will

Electronic chemicals will be top performer

Specialty chemical	U.S. sales[a] ($ millions) 1983	U.S. sales[a] ($ millions) 1990	% of total, 1983[b]	% of total, 1990[b]	Average annual growth 1983–90
Oil field	$ 4,200	$ 6,800	10.3%	11.7%	7%
Agricultural	5,500	6,700	13.5	11.5	3
Electronic	2,500	6,100	6.2	10.5	13
Industrial coatings	4,000	4,900	9.8	8.4	3
Specialty lubricants	3,300	3,600	8.1	6.2	2
Industrial & institutional cleaners	2,900	3,500	7.1	6.0	3
Specialty polymers	1,800	3,300	4.4	5.7	9
Diagnostics	1,500	3,000	3.7	5.2	10
Adhesives & sealants	1,600	2,600	3.9	4.5	7
Plastic additives	1,600	2,300	3.9	3.9	5
Lubricant additives	1,500	1,900	3.7	3.3	3
Food additives	1,200	1,600	3.0	2.7	4
Photographic	1,000	1,600	2.5	2.7	7
Catalysts	1,200	1,600	3.0	2.7	5
Water management	950	1,300	2.3	2.2	5
Textile	780	1,000	1.9	1.7	4
Metal finishing	570	700	1.4	1.2	3
Biocides	520	690	1.3	1.2	4
Cosmetics	520	650	1.3	1.1	3
Specialty surfactants	420	640	1.1	1.1	6
Rubber	470	620	1.2	1.1	4
Reagents	370	520	0.9	0.9	5
Explosives	410	500	1.0	0.9	3
Paper	340	450	0.8	0.8	4
Refinery	260	370	0.6	0.6	5
Paint & coating additives	380	350	0.9	0.6	3
Mining	340	300	0.8	0.5	3
Fuel additives	210	280	0.5	0.5	4
Printing ink	170	210	0.4	0.4	3
Foundry	130	170	0.3	0.3	3
TOTAL	**$40,640**	**$58,250**	**100.0%**	**100.0%**	**5%**

a 1983 dollars. b Column may not add to 100% because of rounding. **Source:** Strategic Analysis Inc.

Earl M. Muetterties Memorial Symposium
University of California, Berkeley
June 22–23, 1984

A special symposium honoring the late Prof. Earl Muetterties, sponsored by the Materials & Molecular Research Division of Lawrence Berkeley Laboratory and the Chemistry Department of the University of California, Berkeley, will be held at Berkeley on June 22–23.

The program features 12 outstanding contributors to the field of inorganic chemistry, with areas of research representing those in which Muetterties made significant contributions. Speakers are Fred Basolo, Northwestern U; John Bercaw, Caltech; John Bradley, Exxon; Lawrence Dahl, U of Wisconsin; Harry Gray, Caltech; Fred Hawthorne, UCLA; Richard Holm, Harvard; Stephen Lippard, MIT; Richard Schrock, MIT; Edward Solomon, Stanford; Henry Taube, Stanford; Patricia Watson, Du Pont.

Registration will be limited to 200 participants. The fee of $100 will include a banquet, mixer, and lunches. Room accommodations at one of three hotels nearby will be arranged by the LBL Conference Coordination Group.

Complete the information below, including $100 registration fee payable to: UC Regents, and send to Muetterties Symposium, Dept. of Chemistry, U.C. Berkeley, Berkeley, Calif. 94720, by June 12. For more information call (415) 642-6710.

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Affiliation

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put them close to the $60 billion mark by 1990.

Nordhoy points out, however, that many segments of the specialty chemical industry are maturing and will grow at rates only close to that of GNP. These include several of the largest segments of the business, such as agricultural chemicals, industrial coatings, specialty lubricants, and industrial and institutional cleaners.

On the other hand, he has tabbed several segments of the industry that will outperform the 5%-per-year average growth rate through 1990. For instance, electronic chemicals, he says, will be the top performer. With an estimated growth rate of 13% annually, sales of electronic chemicals will nearly triple from last year's $2.5 billion to $6.1 billion in 1990. That's good enough to pull electronic chemicals from sixth to third on Nordhoy's list of specialty chemical segments.

Nordhoy includes in electronic chemicals the materials used to make semiconductor devices, printed circuit boards, and such passive components as resistors, capacitors, and hybrid networks. This segment was hit hard by the recession, but it has rebounded to a double-digit growth rate.

Diagnostic chemicals will sport an average 10%-per-year growth rate through 1990, doubling sales volume from last year's $1.5 billion. The development of monoclonal antibody-based immunodiagnostics will mean a rapid growth market for immunodiagnostics, especially for the nonisotopics. Automated instruments and small clinical analyzers for doctors' offices also will expand the market. Meanwhile, the general aging of the U.S. population will have a significant—and positive—impact on the diagnostic chemicals market.

Specialty polymers will be another fast-growing segment of the U.S. specialty chemicals business. Nordhoy says that the growing use of specialty polymers and their modified compounds as structural replacements for metals in the automotive, aerospace, and construction industries will stimulate demand for these products.

As a result, sales of specialty polymers will grow an average 9% per year, reaching $3.3 billion by 1990. Not only will resin producers benefit from this growth, but so will the specialty firms that modify engineering thermoplastics with reinforcing agents such as carbon and glass fibers.

Nordhoy also believes that the oil field chemicals business will grow at an above-average 7%-per-year rate through 1990. Although this business took a severe beating in 1982 and depends directly upon the supply, demand, and price of crude oil, the long-term trend is strong.

The oil rig count may never hit the 4500 level again, but Nordhoy

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sees it growing from its present low level of about 2300. This will pull along with it a higher demand for drilling mud. Meanwhile, the long-term trend toward deeper wells will increase demand for high-performance chemicals. And a pickup in enhanced recovery will boost demand for oil field chemicals.

Sales of specialty adhesives and sealants also will enjoy a 7% average annual growth rate through 1990. These products will benefit from changes in substrates to plastics and higher grades of paper, both of which will require new adhesives. Further growth will take place in the automotive and aerospace industries as plastics and composites gain wider acceptance.

To improve performance, adhesives will continue to replace traditional fasteners. Nordhoy expects particularly strong growth for anaerobics, cyanoacrylates, waterborne systems, and hot melt systems.

If 7 to 13% growth rates don't sound exciting enough, Nordhoy has identified several "high-growth niches" that can boast of expected growth rates of up to 40% annually. In the electronic chemicals segment, for instance, plasma processing materials and materials for photovoltaic cells are growing at much higher rates than the average for electronic chemicals. Nordhoy estimates 40%-per-year growth for these particular products over the next several years.

The market for plasma processing materials is now very small—only several million dollars. But these materials are replacing traditional acids and etching materials. Many experts, says Nordhoy, believe that this technology is the only practical way to etch submicron geometries into the silicon-based devices of the future.

The market for photovoltaic cell materials also is small. Nordhoy puts this market at about $40 million now, but he expects it to exceed $500 million by the end of the decade. These materials, he says, represent an embryonic market opportunity that few companies have noticed.

Despite these and other rapidly growing uses, all is not clear sailing in the chemical specialties business. Some market segments already are mature. Competition is getting tougher as new domestic and foreign companies get into the act. Some companies can't keep pace with the rapidly changing technology. And government regulation has an adverse impact on some specialty businesses.

But what are problems for some companies are opportunities for others. As a result, Nordhoy expects more major chemical companies to increase their stake in specialty chemicals, both through acquisition and internal programs.

Earl Anderson, New York

Some high-growth areas will far outpace the specialty chemical segments of which they are a part

Segment	High-growth area	Average annual growth 1983–90 for segment	Average annual growth 1983–90 for high-growth area
Electronic chemicals	Plasma processing material	13%	40%
	Material for photovoltaic cells	13	40
	Conformal coatings	13	20
	Conductive coatings	13	20
Cosmetic chemicals	Ultraviolet absorbers	3	8
Reagent chemicals	Biochemicals	5	9
Industrial & institutional cleaners	Cleaners for fast-food restaurants	3	8
Specialty lubricants	Semisynthetic and synthetic cutting fluids	2	10
Catalysts	Hydrotreating catalysts	5	10
Water management chemicals	Light industrial, institutional, and commercial businesses	5	10
Diagnostic chemicals	Nonisotopic immunoassay reagents	10	20

Source: Strategic Analysis Inc.

Announcing DuPont's four newest "Idea Intermediates."

The newest additions to the family of DuPont "Idea Intermediates," shown on the opposite page, are:

DBA Dibasic Acid
$HOOC(CH_2)_n COOH$
n = 2,3,4

Sodium Styrene Sulfonate

CH2=CH
SO3Na

Triphenylboron
$B(C_6H_5)_3$

Triisopropyl borate
$B[OCH(CH_3)_2]_3$

If you would like more information on any of these four products, write on your company letterhead to: DuPont Company U.S.–Room G40109, Wilmington, DE 19898; EUROPE–P.O. Box CH-1211, Geneva 25, Switzerland; JAPAN–11-39 Akasaka 1-chome, Minato-ku, Tokyo 107.

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JUNE 11, 1984

CHEMICAL & ENGINEERING NEWS

PRELIMINARY PROGRAM
ACS Philadelphia meeting
Page 81

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for the chemical industry
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Cover: Sharon H. Wolfgang

CHEMICAL & ENGINEERING
NEWS

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JUNE 11, 1984

News of the Week

- **Edward A. Knapp leaves head post at the National Science Foundation; Erich Bloch has been named as successor.** Page 6
- **Field testing for genetically altered bacteria reapproved after first approval was halted by a federal judge.** Page 7
- **Du Pont priming for a major expansion of its waste treatment services.** Page 7
- **U.S. chemical trade surplus plummeted in April for second month in a row.** Page 8
- **Successful cloning of gene fragments from extinct creature announced by researchers at Berkeley.** Page 8

Business

Large-volume mineral acids could be entering period of slower growth; biotechnology companies report sharply higher revenues; Du Pont to market Swiss line of ultracentrifuges. **Page 10**

International Business

Methanol hailed as most likely substitute for gasoline; new, small company aims to supply fuel methanol to Japan. **Page 14**

Government

Environmental laws are being crafted in this session of Congress to the tune of complaints from critics. **Page 18**

Science/Technology

New insights offered on stereochemistry may clarify confusing concepts; hydroquinone production at Tennessee plant to use process that could prove more economical. **Page 21**

Education

International study indicates U.S. science education has improved since similar testing of fifth and ninth graders in 1970. **Page 26**

ACS News

Latest CPR report on mass firings of chemists shows increase in terminations of older chemists. **Page 79**

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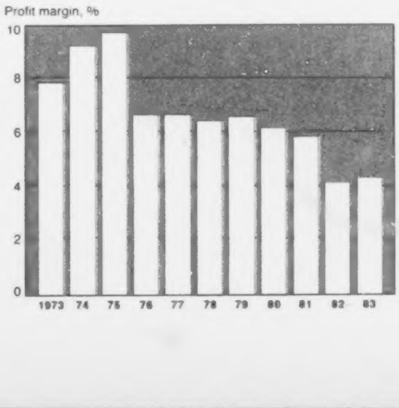


Facts & Figures

1983 was a recovery year for the U.S. chemical industry as economic improvement led to expanded production. Page 32

Recovery Slows For Large-Volume Acids

Sulfuric and phosphoric acids may be entering period of 4% or so annual growth in late 1980s, with overcapacity becoming commonplace

Bruce F. Greek, C&EN Houston

Producers of the two major-volume mineral acids—sulfuric and phosphoric—are beginning to see that 1984 will not be nearly so strong a year as was originally forecast. With the year half gone, and the first half traditionally the better half because of the spring fertilizer season, results have been disappointing. Now, according to more realistic forecasts resulting from first-half results, the rest of the decade could be one of a shift from past trends.

Production of sulfuric and phosphoric acids will be up 8% or so in 1984. Although that falls below most producers' expectations, it may seem high compared to rates now talked about for the rest of the 1980s. Forecasters aren't discounting the possibility of more recessions in the decade, which could affect demand for these acids—especially sulfuric. And recoveries could produce large gains over the recessions, as has happened recently. But a smoothed curve through the late 1980s could show annual production growth rates of 4% or less.

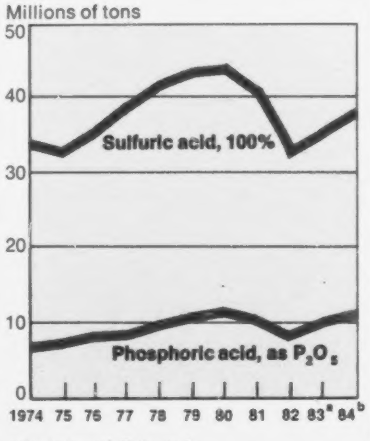
With these kinds of annual growth rates forecast now, producers of these acids face a continuation of low average plant operating rates. The rates will rise slowly from current levels, assuming the dearth of plans for plant expansions also continues. But it will be a long time before operating rates will approach 100% of nameplate capacity, much less surpass it as has happened in the past for phosphoric acid.

About the only plant expansions expected for sulfuric acid are those that result from the need to do something with the sulfur dioxide produced in smelting operations to meet air pollution control rules, or those of the debottlenecking type as part of efforts to improve efficiencies. Expansion of phosphoric acid plant capacity, if any, would be to make wet-process acid as the result of some unexpected rise in demand for fertilizers, either domestically or for world export markets.

Key Chemicals

It could be a long time before capacity currently shut down is reactivated, if it ever is. Usually producers of phosphoric acid prefer to run plants above the nameplate level for short periods during high demand for fertilizer products rather than to start up other units for just a short time. Sulfuric acid plants, if fully shut down, rust quickly, making restart of a plant expensive and unlikely if it is old.

Output of big acids up, but remains below 1980 high



a Preliminary. b Estimated.
Sources: Department of Commerce, C&EN estimates

Financial incentives are there for both plant shutdowns and delay of capacity additions. Prices of both sulfuric and phosphoric acids have improved during 1983 and early 1984. A good part of the price improvement, however, results from a pass-through of increased sulfur prices. The real price increases after discounting have not been large enough to provide sufficient return on investment to make additions or in some cases to retain plants.

Just as production volumes are not yet back to historical highs, neither are sales. A peak in production occurred in 1980 when 44 million tons of sulfuric acid and 11 million tons of phosphoric acid (measured as P_2O_5) were made. This year, even with the economic recovery, sulfuric acid production will do well to reach 37.5 million tons. Phosphoric acid will almost reach the previous high at 10.8 million tons of P_2O_5.

The value of production of the two acids in 1984 will total about $4.5 billion, still well down from the value in 1980 of about $5.25 billion. No adjustment for inflation is included, so producers' incomes are even relatively lower.

Of the two acids, sulfuric suffers more. It accounts for more of the decline in production and sales values. That's what might be expected for a product with the greater overcapacity. This year production of sulfuric acid will represent less than two thirds of installed capacity.

For details of the near-term outlook for sulfuric and phosphoric acids, please see the following pages.

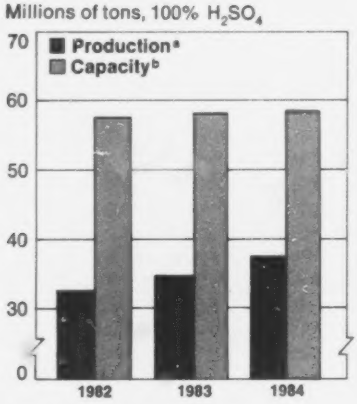
Key Chemicals

H_2SO_4

Sulfuric acid

- ***Demand growing***
- ***Capacity up slightly***
- ***Prices discounted***

PRODUCTION/CAPACITY



[a] From all sources. [b] First quarter.

HOW MADE

Sulfur dioxide made by burning sulfur or recovered from smelting, oxidized, and reacted with water

MAJOR END USES (U.S.)

Fertilizer manufacture 70%; chemical manufacture, metals processing, petroleum refining 5% each

FOREIGN TRADE

Exports—could fall below 250,000 tons in 1984, imports—could exceed 500,000 tons in 1984

PRICES

List prices, virgin acid, $55 to $90 per ton, depending on location; smelter acid, $20 to $50 per ton; discounting remains heavy.

COMMERCIAL VALUE

$2 billion for estimated production, 1984

Production of sulfuric acid continues its plodding recovery. In fact, the annual increase in production of this workhorse of the chemical industry during 1984 will be greater than 1983's increase. But it will be several more years before production reaches the level experienced in 1980.

Industry sources expect 1984 sulfuric acid output to rise 8 to 9% over 1983's to about 37.5 million tons (measured as 100% sulfuric acid). That amount would be 15% above 1982 production, which was the lowest for any year since 1975.

After 1984, production growth for sulfuric acid will slow down, perhaps leveling off at a rate of less than 3% per year. Hence, with average growth rates such as these forecast through this decade, a return to production greater than the 44 million tons produced in the record year of 1980 will take quite some time. Breaking through the 44 million ton-per-year level thus might not happen until 1990, if forecasts of slow growth prove accurate.

Installed capacity to make sulfuric acid far exceeds not only current production but also any forecast levels of output. Considerable sulfuric acid capacity now is idle and more is expected to be shut down between now and 1990. However, it is difficult to obtain a good fix on operable capacity because sulfuric acid plants are shut down and allowed to rust before officially being scrapped.

Including those facilities shut down, but not scrapped, operating rates of sulfuric acid plants during 1984 likely will average about 65% of installed nameplate capacity—better than the 60% rate in 1983 and the 57% rate in 1982, but not much. And, of course, actual rates are higher, considering that the shut-down plants are still included in the figures. But sulfuric acid producers, though not liking it much, have grown to accept low average operating rates. They will operate a plant at very low levels to keep the units warm. This minimizes corrosion and keeps it available should demand surge.

During the first and fourth quarters of a year, production runs much higher than the yearly average for sulfuric acid plants as producers work to meet demands for making phosphoric acid for fertilizers. Later, in the spring and summer, plants are run at much lower rates and some acid is moved into nonfertilizer markets if they are available. All these factors also make forecasts of operating rates difficult.

For many years to come, new capacity to make sulfuric acid will be limited largely to that needed to meet pollution control requirements, mainly at smelters. The current view for other production facilities is that enough capacity exists to meet any demand that could possibly come from any of the major uses of sulfuric acid. Only an unusual situation would cause a producer to build a plant to supply sulfuric acid for making phosphate fertilizers, for refining, or for any of the many merchant demands.

Sulfuric capacity to be shut down and scrapped will be of many types. Most in danger will be those units using smelter gases if it becomes clear that the smelter itself will be shut down. This could happen for a number of reasons, such as an uneconomic ore supply. Less clear is the future of sulfuric acid plants at fertilizer complexes. These are a wide mixture of new and old units with the usual variations in efficiency and depreciated value that can affect decisions on whether producers will keep them operating or not. Sulfuric acid facilities that generally supply merchant markets seem to be under pressure because of significant declines in demand for downstream products.

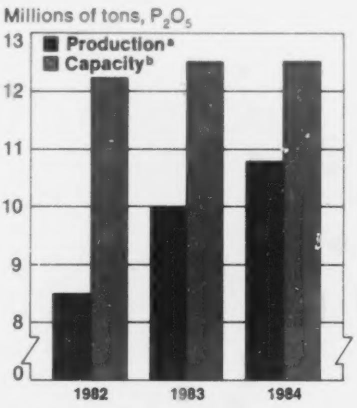
As in the past, sulfuric acid going to make fertilizers of one kind or another dominates consumption, making up more than two thirds of the total. The outlook for fertilizers depends on many factors ranging from weather to politics, with economics often taking second place. In 1984 and 1985, fertilizers are accounting for their proportional share of the increase in demand for sulfuric acid. Demand for fertilizers has not come up to most expectations this spring, even with the end of the payment-in-kind program. Inventories are being built again and hopes are pinned on good movement of fertilizers this fall. If that happens, then the demand for sulfuric acid in 1984 could meet present forecasts—but only with a strong fourth quarter.

Phosphoric acid

H_3PO_4

- ***Demand up again***
- ***Capacity on hold***
- ***Prices discounted***

PRODUCTION/CAPACITY



[a] From all sources. [b] First quarter.

HOW MADE

Reaction of phosphate rock with sulfuric acid; burning of elemental phosphorus and subsequent reaction with water

MAJOR END USES (U.S.)

Fertilizers 85%, detergent materials 5%, food and feed materials 5%

FOREIGN TRADE (as acid)

Exports—slumping to about 700,000 tons of P_2O_5, imports—tiny, possibly about 25,000 tons of P_2O_5

PRICES

List prices about $300 per ton of P_2O_5, discounts heavy

COMMERCIAL VALUE

$2.5 billion for estimated production, 1984

"It's not as we hoped, nor even as we expected." In this way, one industry source summarizes the current slowdown in phosphoric acid demand, which counters earlier expectations for sizable growth in 1984. These expectations, formed last fall, were based on such factors as the end to the government's payment-in-kind (PIK) crop set-aside program, higher prices for farm commodities, and increased exports.

Although PIK has ended for practical purposes, the expectations have gone awry. Commodity prices, though up somewhat, remain below most farmers and fertilizer producers' forecasts. Thus, domestic phosphate fertilizer demand is less than expected. The strong dollar continues to dampen exports of phosphate fertilizers.

These are the other important reasons why 1984 production of phosphoric acid will do well to be up 8% to 10.8 million tons (measured as P_2O_5). Production in 1983, still a preliminary estimate, was up more than 17% from 8.5 million tons in 1982, the lowest annual production since 1976.

Most phosphoric acid produced in 1984 will be wet acid, made by acidulating phosphate rock with sulfuric acid. However, about 7% or less of total production, or about 700,000 tons as P_2O_5, will be made from elemental phosphorus produced in electric furnaces—furnace acid. This 10.1 million tons of wet acid now seems dependent on developments this fall in fertilizer demand after most of the harvest is in. If crop yields, particularly corn, are good and farmers' receipts are better, then some pickup in fertilizer production to build inventory for the spring season will occur.

As it stands now, estimates of the 10.1 million tons include some 300,000 to 400,000 tons of wet acid output going into phosphate fertilizer inventories. Inventories have been built up some this spring as fertilizer demand fell below anticipation. As a result, some production plants are expected to be shut down two to four weeks earlier than usual for maintenance and vacations. The size of the inventories overhanging the potential fall market is not clearly known yet, but it could be up more than preliminary estimates show. The inventories could lead to an unfortunate return to the surpluses that were worked off at the expense of profits during 1982 and 1983.

The rest of the phosphoric acid production is expected to be consumed as various fertilizers or exported as the acid, 9.0 million to 9.3 million tons; as animal feed materials, about 500,000 tons; and other uses, mainly detergent materials, some 100,000+ tons. Clearly then, more than 90% of all wet-process phosphoric acid goes into fertilizers directly, or for export and subsequent manufacture into fertilizers. So fertilizers dominate phosphoric acid. How fertilizer demands are influenced by weather, farm politics, exports, and other nonagronomic factors quickly reflects back to phosphoric acid manufacture.

Capacity to make phosphoric acid has leveled off at about 12.5 million tons of P_2O_5. All but about 750,000 tons are wet-process acid plants. Both wet-process and furnace acid plants are shut down. Some have been down for quite some time and may never restart. Counting these questionable plants as still potential capacity, the operating rate likely will average above 85% for all of 1984.

This spring, for example, weather again has been a strong factor in fertilizer demand resulting in earlier than usual shutdown of some plants. Rains have slowed field work. Consequently, planting is being hurried with the result that at a significant number of farms, initial fertilizer application will be passed up—especially in the case of corn—for a later side dressing with nitrogen. This will work to the detriment of phosphorus use.

Exports of both phosphoric acid and fertilizer derivatives such as diammonium phosphate are expected to be down this year. The strong dollar continues to hamper exports as do the large debts from buying oil being run up in developing countries.

On balance, producers of phosphoric acid will have a better year, but not so good as had been hoped. It will not be so good in terms of plant operating levels as in some past years. This development of unexpectedly lower operating rates has begun to put some pressure on prices, keeping profitability low.

Product sales buoy biotechnology revenues

Moving swiftly toward commercialization, companies in the biotechnology field reported sharply higher revenues for the first quarter of 1984. For a dozen biotechnology-based firms, composite revenues were 77% higher than those in the corresponding 1983 period.

Most significant, product sales have begun to constitute a noticeable portion of a revenue mix that previously had consisted nearly exclusively of R&D contract fees and interest income. On many income statements, product sales appeared for the first time, and, on some, made up the fastest-growing component of revenue.

At Genex, for example, which is producing L-phenylalanine for G. D. Searle & Co.'s aspartame, product sales rose to \$3.8 million—63% of operating revenues—from nothing in the year-earlier quarter. Monoclonal Antibodies attributed most of its 241% revenue increase to sales of its line of pregnancy-detection kits. At Molecular Genetics, sales of the company's first product—a monoclonal to prevent calf scours—made up a third of operating revenue compared to less than 1% a year before.

It is true, on the other hand, that product sales still make up little or no part of revenue at such major companies as Genentech, Cetus, and Biogen. Nevertheless, the deduction that there is a widespread, ongoing metamorphosis from R&D operations to integrated manufacturing companies—a shift predicted by many analysts—appears indisputable.

At the same time, earnings remain negligible or nonexistent as companies continue to plow revenues back into R&D, staff increases, and plant construction. For most biotechnology-based firms, the presence or absence of net income appears to have less to do with corporate health than with how much speed and independence they want to maintain.

Biogen, for instance, nearly doubled its first-quarter loss, despite raising revenues 49%. "Our net loss is in keeping with our strategy of using our financial resources to accelerate product development," chairman Walter Gilbert said.

Other deficit-reporting firms had similar explanations. And those companies with profits were equally anxious to put the bottom line in this special context. "The company is intentionally operating at a modest income level as we concentrate our resources toward early market entry," said Genentech president and chief executive officer Robert A. Swanson.

David Webber, New York

Biotechnology revenues increased in first-quarter 1984

	FIRST-QUARTER 1984[a]					
	Operating revenue[b]	Total revenue	Operating revenue as	Earnings[c]	Change from 1983	
	($ millions)		% of total	($ millions)	Revenue	Earnings
Biogen	\$4.17	\$ 6.03	69.2%	\$−3.63	49%	def
BioTechnica International	na	0.40	na	−1.05	740	def
Biotechnology Development	0.26	0.34	78.6	−0.10	367	def
Centocor	na	2.53	na	0.01	97	nm
Cetus	9.40	12.03	78.1	0.11	38	−58%
Damon Biotech	0.76	1.40	54.6	−0.62	153	def
Genentech	na	15.29	na	0.39	56	67
Genex	5.40	6.00	90.0	−1.70	275	def
Hybritech	na	6.06	na	0.14	97	nm
Molecular Genetics	1.94	2.61	74.1	−0.06	126	def
Monoclonal Antibodies	na	0.78	na	−1.09	241	def
Ribi ImmunoChem	0.15	0.23	62.5	−0.07	53	def

a For January–March 1984 period, in general. Companies have various fiscal years. b Includes revenue from R&D contracts, product sales, and royalties, but excludes interest income. c Excludes extraordinary credits. **def** = deficit. **na** = not available. **nm** = not meaningful. **Source:** Company financial statements

Du Pont licenses line of ultracentrifuges

Du Pont is a company known for generating new products internally, but one aspect of the firm's current push into emerging businesses in life sciences and electronics has been an apparently increased willingness to use acquisitions, licensing agreements, and academic research arrangements to advance its product development.

The acquisitions of New England Nuclear and Solid State Dielectrics and a research deal with Harvard medical school are recent examples of this trend. Now the company has moved to bolster its clinical instrument business with a license to market in the Western Hemisphere a line of ultracentrifuges manufactured by Kontron, a Swiss subsidiary of Hoffmann-La Roche. Eventually Du Pont expects to assemble the instruments in the U.S. and, ultimately, manufacture them here. The diagnostic and bioresearch systems division of the company's nine-month-old biomedical products department will handle the line.

The computerized ultracentrifuges, seen by Du Pont as a direct thrust at Beckman Instruments' dominance of the \$50 million global market, are part of the company's effort to tap into the burgeoning bioresearch field with state-of-the-art separation technology and instrumentation. Though the ultracentrifuges are not a particularly large market, they jibe with the company's plan to expand its position in the bioresearch field with a series of relatively small products while waiting for the biomedical products department to generate a "home run ball," something that will take time, remarks Donald C. Sutherland, director of the diagnostic and bioresearch systems unit.

Sutherland points out that the licensing deal does not indicate a reduction of in-house R&D. Instead, he says, it is a way to avoid duplication of effort in technology development. "It could be the forerunner of other such arrangements," he says. □

Study Indicates Some Improvement In U.S. Science Education

Counter to trends in recent studies, new survey shows improved overall science scores among fifth and ninth graders, compared to 1970's

James H. Krieger, C&EN Washington

Preliminary analysis of the Second International Science Study (SISS), sponsored by the International Association for the Evaluation of Educational Achievement, is starting to yield results—and they run counter to the current conventional wisdom.

In short, the results show that U.S. school children know more about biology and physical science today than school children did in 1970—although they know less about space travel.

"There is a richness of rhetoric but a dearth of empirical data about science education in our schools," says Willard J. Jacobson, professor of natural sciences at Teachers College, Columbia University, and national research coordinator for SISS. If preliminary findings hold up in subsequent analysis, Jacobson sees the study providing evidence that U.S. science teachers "are doing something right," despite the recent spate of reports critical of education in the U.S.

Recent criticism of U.S. science education has been based heavily on results of studies by the National Assessment for Educational Progress and on declining scholastic aptitude test (SAT) scores. Jacobson admits the SAT data aren't easily explained away, but he feels the NAEP data can and have been misinterpreted.

In any event, educators will soon have the SISS data to ponder. The preliminary results were presented recently by Jacobson and his colleagues at the annual meeting of the American Association for the Advancement of Science, held recently in New York City.

The current data are based on testing for SISS that took place during 1983 in public and private schools. Almost 5000 school children—2909 in fifth grade and 1958 in ninth grade—were tested in more than 200 schools. Overall science achievement increased 6.5% for fifth-grade students and 5.2% for ninth-grade students, compared to results of the First International Science Study conducted in 1970. The only questions that received fewer correct answers from both grades in 1983 related to the moon—one asking how long a rocket trip to the moon would last and the other asking for the source of sunlight.

C&EN staff photos

Jacobson: evidence that U.S. science teachers are doing something right

For fifth graders given 26 questions appearing in both studies, students in 1983 were less likely to know that a ball falls to the ground because it is pulled by Earth, but better able to read a thermometer and correlate their readings with data presented in a chart. Also in 1983, more fifth graders knew that a person's pulse and breathing rate

Second International Science Study testing shows variable achievement

Grade 5	
Correct answers (total test)	58.7%
Correct answers (biology items)	62.1%
Correct answers (physical science items)	55.7%
Average (mean) total score on 48 items	28.2
Low score	6
High score	46
Standard deviation	7.8

Grade 9	
Correct answers (total test)	61.4%
Correct answers (biology items)	64.7%
Correct answers (chemistry items)	54.0%
Correct answers (physics items)	61.3%
Correct answers (Earth science items)	61.1%
Average (mean) total score on 60 items	36.8
Low score	7
High score	59
Standard deviation	9.6

would increase during a 50-meter race.

For ninth graders given 33 questions appearing in both studies, students in 1983 were better able to read a graduated cylinder and select a drawing of an electrical circuit most likely to be in a box described by data in the question. They had trouble with some factual questions. For example, fewer, though most, children tested knew that the heart was not in the abdomen and that the sun was the source of energy for photosynthesis.

SISS associate national research coordinator Rodney L. Doran of the State University of New York, Buffalo, points out that the only statistical analysis of students carried out so far relates to the effect on achievement of gender and strata (public or private school). The results for the fifth grade, he says, are easy to interpret and are consistent with previous science education research. There is a significant effect favoring males, a significant strata effect favoring private schools, and no significant interaction among these variables.

The results for ninth grade, Doran says, are more complex. There is a significant gender effect favoring males. However, the strata effect isn't significant. Further, there is a significant interaction effect as a result of females from the private schools surpassing their male cohorts. Doran says further analyses will attempt to explain this "intriguing effect."

In addition to the tests, students were given questionnaires and opinionnaires. For example, an opinionnaire asked students to react to statements concerning science, school, and the study of science—for instance, "The science taught at school is interesting." And a science learning activities questionnaire asked students to report the frequency with which they engaged in various science learning activities—for example, the frequency that "the students themselves do experiments as part of the science lessons."

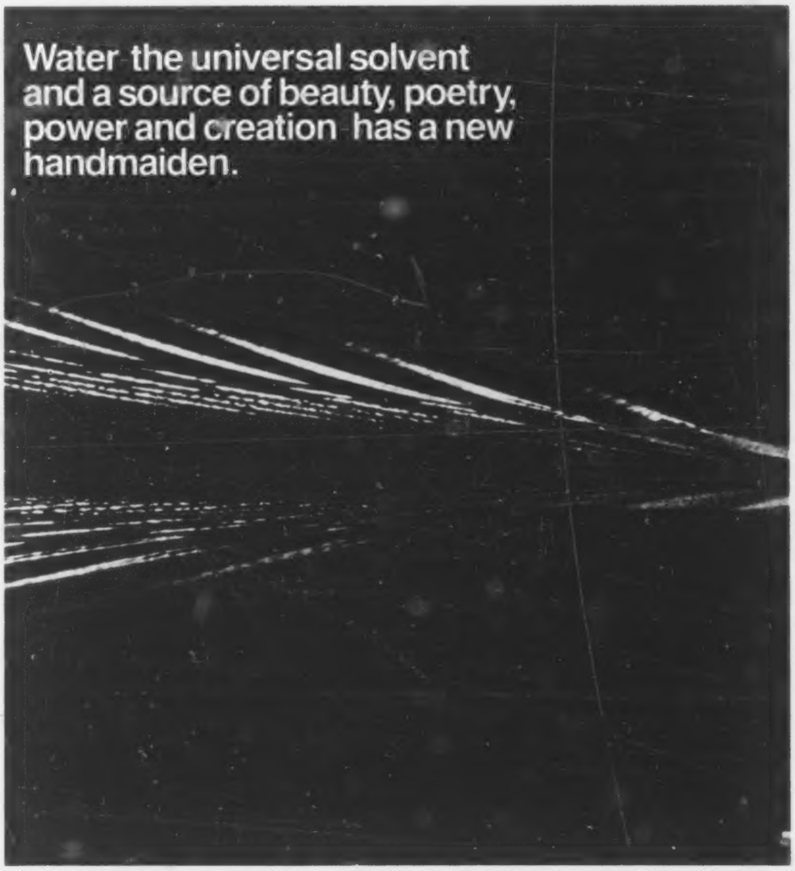
Doran notes that a number of anomalies exist in the data that need further investigation. Ninth graders, he says, find science both less enjoyable and less interesting than fifth graders. Yet, their enjoyment of school is about the same, although educational aspirations decrease in the ninth grade. At the same time, there is an increase in the use of small groups and student participation in science activities in the ninth grade. These findings, Doran says, aren't consistent with the gains in achievement on items assessing higher thinking skills. Jacobson expects to have results for SISS from testing of 12th-grade students—those in physics classes and those not studying any science—this fall.

The test items and questionnaires for SISS evolved through a rather elaborate process. Among other elements, a science curriculum case study was prepared by each participating country. The case study for the U.S., for example, describes the demographics of science education in the U.S., patterns of science offerings, goals for science education programs, objectives in science education programs, methods used in developing curricula, and topical outlines of science content areas.

A part of this activity involved ratings of U.S. science curricula, in which knowledgeable science educators were asked to make judgments

Students show improvement on identical "bridge" items

	Grade 5			Grade 9		
Average test score, %	**Number of items**	**1970**	**1983**	**Number of items**	**1970**	**1983**
Biology	9	49.7%	58.9%	10	59.9%	65.6%
Physical science	17	59.3	64.4	23	51.9	56.8
Total	**26**	**56.0%**	**62.5%**	**33**	**54.3%**	**59.5%**


Water the universal solvent
and a source of beauty, poetry,
power and creation has a new
handmaiden.

Doran: the effect of science education in the 1970s has been positive

about the extent of coverage and degree of emphasis of the various content areas at each of the grade levels. The ratings were quantified by asking participants to rate on a scale from 0, indicating the content area was not included in curricula, to 3, indicating a high level of coverage with major emphasis for all or most students. Ratings were made for traditional science areas, such as chemistry and physics, as well as for nontraditional areas, such as environmental science and history and philosophy of science. One finding: Chemistry generally receives less coverage and emphasis among traditional science areas than do physics, biology, and Earth sciences.

The analyses of curricula were used in preparing items and questionnaires for trial testing, the results of which were used in further refining the testing materials. But Jacobson expects the curricular analyses to be of considerable value in their own right, representing as they do an extensive survey of the science education literature, local science programs, and the most widely used science textbooks, as well as the ratings of curricula.

The sample for testing was provided by the National Center for Educational Statistics. It drew up a representative sample of about 250 schools at each grade level, stratified on the basis of public and private schools. Since some schools had grades at more than one of the levels, the total sample was 521 public and 47 private schools, representing about 87,000 public elementary/secondary schools and 19,600 private schools. For grade five, 50% of available schools participated, although for grade nine, only 36% of available schools did.

A question raised by such testing is how representative the sample is of the nation as a whole. Doran points out that various analyses show that it is.

Doran, who was not involved with the first study, feels that a few of the questions from that study were poorly written. Still, there wasn't any choice but to use the questions, he says, if a comparison between the first and second studies was to be made.

Nevertheless, Doran says, the preliminary analysis has shown that the effect of science education in the 1970s has been positive and significant gains in overall achievement at both grade levels. This is especially true for items requiring higher thinking abilities. However, there has been little change in the patterns of achievement between the results of SISS and those of other science studies: Sex differences in science achievement increase with schooling; biological science items are easier than physical science items; and ninth grade outperforms fifth grade by about the same margin. □

SISS is an international effort

The Second International Science Study (SISS) is a study of science achievement and the conditions under which science is studied and learned. A cooperative research study designed to review the state of elementary and secondary science education around the world, it is sponsored by the International Association for the Evaluation of Educational Achievement (IEA). For SISS, 28 countries are participating, many of them having taken part in the first study. Funds for the U.S. study have been provided by the Spencer Foundation, Chicago.

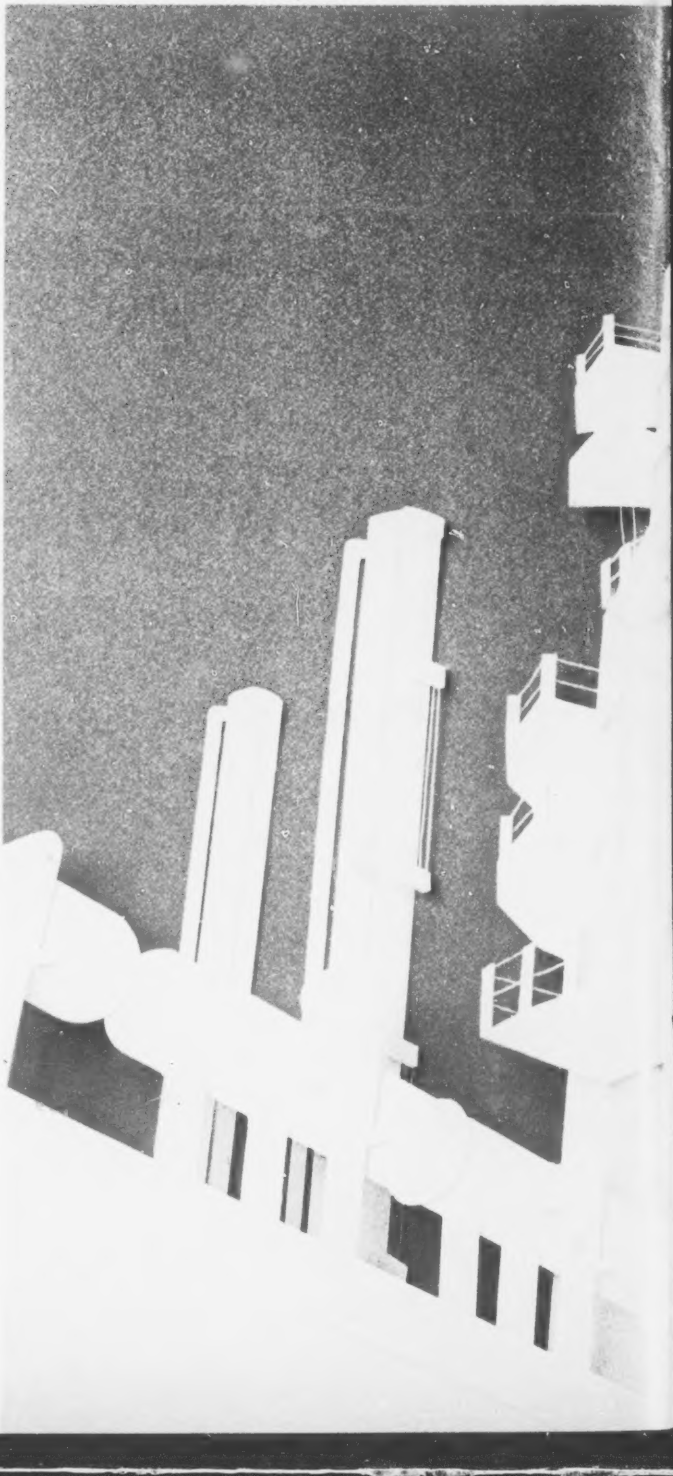
Countries participating in SISS include Australia, Botswana, Canada, China, Finland, Ghana, Hong Kong, Hungary, Israel, Italy, Japan, Mexico, Netherlands, Nigeria, Norway, Papua New Guinea, Philippines, Poland, Singapore, South Korea, Sri Lanka, Sweden, Tanzania, Thailand, U.K., U.S., Venezuela, and Zimbabwe.

In each participating country, there is a national committee that advises on broad policy issues related to the national study. Most of the committees are composed of science educators, scientists, science teachers and supervisors, and people with skills useful in plannning and carrying out the study. The national research coordinators from each of the countries constitute an International Study Committee (ISC), which makes the major policy decisions for the international study. There is also a steering committee that plans agenda for ISC meetings, undertakes detailed work on curriculum analyses, oversees test and questionnaire development and preparation of manuals, and plans for data analysis and general supervision of the study. The international headquarters for the study are at the Australian Council for Educational Research, Victoria, and the international coordinator is Malcolm Rosier, chief research officer at the Australian council.

Although each country is conducting its own study, there are international core items in the achievement tests, and questions and statements that are common to all the questionnaires and opinionnaires being used. In this way, each country can analyze its findings within the context of corresponding data from the other countries.

There are plans in the U.S. for four reports to be published over the next couple of years. These reports include "Achievement in Science Education in the U.S.: Student, Teacher, School and Community Factors that Correlate with Science Achievement," "Science Education in the 1970s and 1980s," "Science Education in the U.S. and in Other Countries," and a report to policy-making groups and to the public, "Science Education in the U.S."

Facts &



for the chemical industry

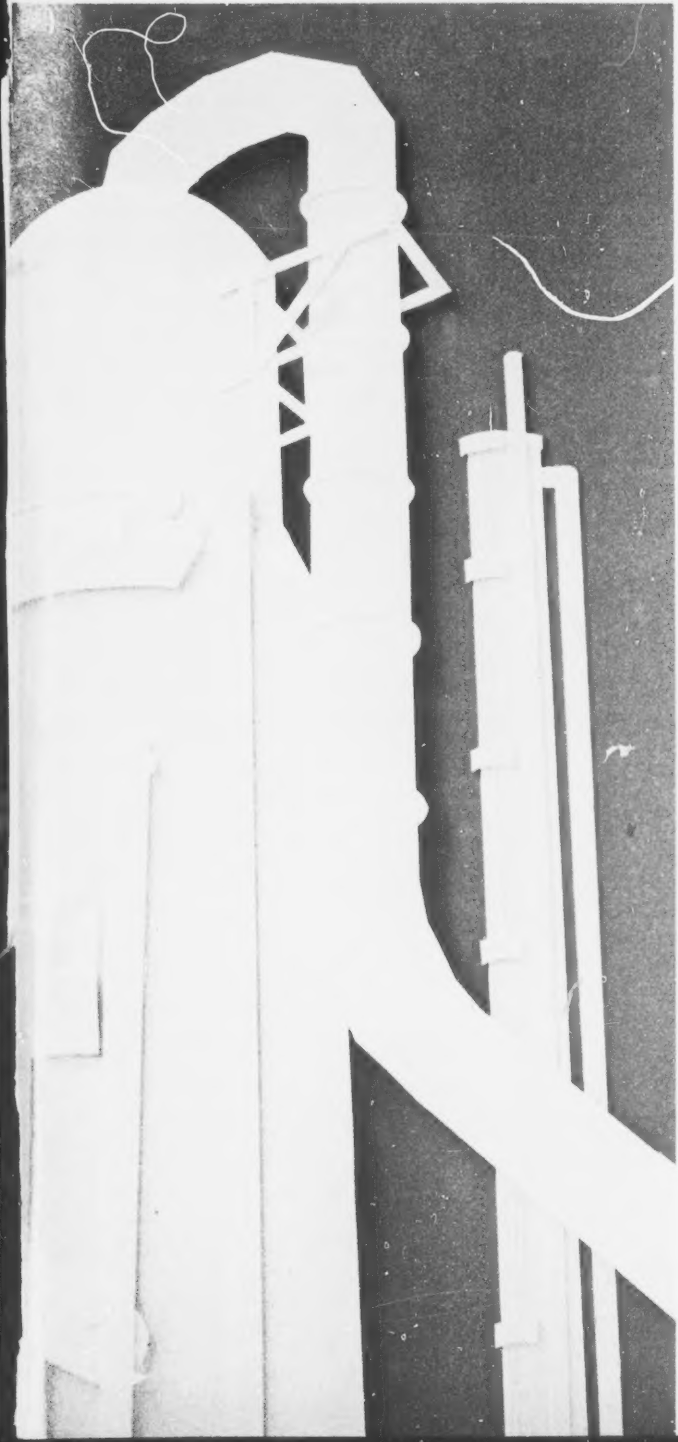
Last year, for the first time in four years, the statistics that measure the progress of the U.S. chemical industry generally had a favorable cast. Fueled by a strong recovery in most of its key markets, such as automobiles, housing, appliances, and apparel, the industry increased its output steadily during 1983. By year's end, production had recovered to about the same level where it had been before the painful 1981-82 recession.

The numbers look good, however, largely because they are being compared with the depressed results of the year before. Stacked up against figures for the late 1970s, last year's data look considerably less bright. So far, the decade of the 1980s has been a period of unsatisfactory growth, in terms of volume of production but even more so in profitability, for U.S. chemical producers.

Nevertheless, last year's expansion continues unabated during the first half of 1984. Industry executives, therefore, are just about unanimous in predicting further growth during the current year, although probably at a more modest rate than during the strong 1983 recovery.

The following pages of C&EN's annual Facts & Figures issue set forth the statistics that gauge the industry's performance, not only in the U.S. but abroad as well. They contain data gathered from a variety of sources, including government agencies, trade associations, international organizations, and the companies themselves that operate in the diverse and far-flung chemical industry. These data have been treated by the C&EN staff, in many cases, to develop analytical measures and comparisons in order to add dimension and perspective to the recent record of the industry.

Figures



at a glance

Section One: Production
It was all uphill for output in the U.S. chemical industry last year. Severely depressed at the end of 1982, production moved steadily higher month by month throughout 1983. For the year as a whole, total volume for chemicals and allied products was 10% higher than in 1982. Setting the pace, as usual, were plastics, with output up 20%. But for inorganic chemicals, the record was spotty, as cutbacks in agricultural acreage hurt demand for fertilizer chemicals. **Page 34**

Section Two: Finance
Chemical companies' financial reports improved significantly during the second half of 1983. With demand rising, shipments were 9% higher than in 1982. And the belt-tightening that had been instigated by the recession resulted in an even stronger showing for profits. **Page 41**

Section Three: Efficiency
Increased production coupled with the stringent cost-cutting measures that swept the chemical industry during the recent recession years has resulted in a marked improvement in the industry's productivity and a steep decline in unit labor costs. Plant operating rates also are much more favorable. **Page 56**

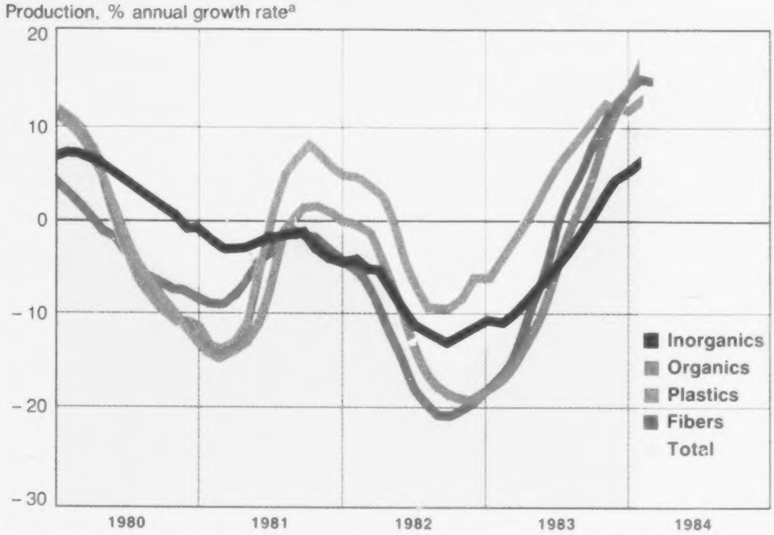
Section Four: Employment
Although employment in the chemical industry has been rising slightly in recent months, the total number of people at work in the industry last year was the smallest, on average, for any year since 1976. **Page 59**

Section Five: Foreign Trade
World trade in chemicals sagged for the third year in a row as nearly all the major chemical-producing countries experienced a drop in exports. For the U.S., the decline was less than 1%, but meanwhile imports of chemicals were considerably higher, topping $10 billion for the first time. Consequently, the U.S. industry's vaunted trade surplus narrowed to $9 billion, the lowest it has been since 1978. **Page 61**

Section Six: Foreign chemical industries
Recovery was the rule for chemical producers throughout the world, although in most cases the pace lagged that in the U.S. Increased demand, firmer prices, and the closing of unneeded capacity bolstered profits for chemical firms in Western Europe. The fortunes of chemical companies in Japan likewise were improved. The situation in Canada was similar, although high costs there have hurt the chemical industry's competitive position in world markets. **Page 63**

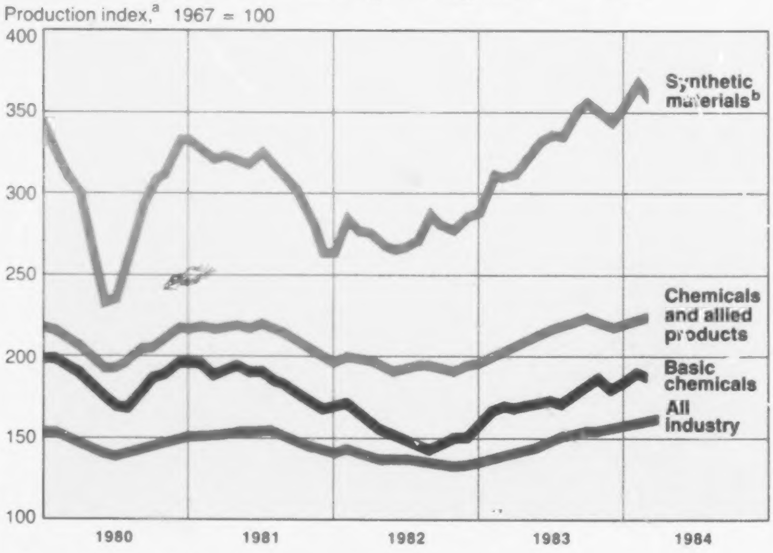
Output makes a strong recovery

Chemical growth rate climbs roller coaster in 1983



[a] Average running annual growth rates in production of major plastics, inorganic and organic chemicals, and all chemicals, and in shipments of man-made fibers. **Sources:** International Trade Commission, Bureau of the Census, Society of the Plastics Industry, Textile Economics Bureau

Chemical output rose steadily during most of 1983



[a] Seasonally adjusted. [b] Includes plastics, synthetic rubber, and man-made fibers.
Source: Federal Reserve Board

After a miserable 1982, U.S. chemical producers made a strong recovery in 1983, increasing output 10%. To put things in perspective, however, at its peak for 1983, in October, production of chemicals and allied products was only slightly above the highs of early 1981. A year of steady growth had brought the chemical industry only back to where it was three years earlier, before the recession started.

Strongest gains were made in production of synthetic materials, which grew nearly 20% in 1983. Man-made fibers output rose 18% from 1982, led by large increases in nylon, olefin, and textile glass production. Both cellulosic and noncellulosic fibers, however, still are being produced at levels far below 1979's highs.

Plastics output, in contrast, surged well past prerecession levels to a new high. Production of thermosetting resins, led by phenolics and other tar acid resins, rose 22%. Among thermoplastics, polyamide output increased a spectacular 41%, following a decrease of 27% in 1982.

Basic chemical production grew a healthy 12% in 1983. Output was up in every category—all of which had experienced double-digit declines in 1982. Organic chemicals production, buoyed by the recovery in polymers, rose 15%. Acids and fertilizer materials managed to grow a modest 4%, even though U.S. production, consumption, and exports of fertilizer declined in 1983 for the second year in a row.

Chemical products, which didn't do so badly as the industry as a whole in 1982, similarly didn't make so strong a recovery in 1983, with production rising only 4%. Still, drugs and medicines, soap and toiletries, and paints all had increases in output. Only production of agricultural chemicals continued to decline, albeit at a slower rate than in recent years.

TOP 50 CHEMICALS: Organic chemicals rebounded much more than inorganics in 1983

Rank			Billions of lb		Common units[b]		Average annual growth			
1983	1982[a]		1983	1982	1983	1982	1982–83	1981–82	1978–83	1973–83
1	1	**Sulfuric acid**	69.45	65.36	34,725 tt	32,680 tt	6.3%	−19.7%	−3.3%	0.8%
2	2	**Nitrogen**	42.03	35.07	580 bcf	484 bcf	19.8	−1.2	8.2	9.8
3	5	**Lime[c]**	28.80	28.15	14,400 tt	14,075 tt	2.3	−25.5	−5.8	−3.2
4	4	**Oxygen**	28.73	28.81	347 bcf	348 bcf	−0.3	−19.3	−4.1	−1.1
5	6	**Ethylene**	28.59	24.50	28,586 mp	24,501 mp	16.7	−16.7	1.9	2.5
6	3	**Ammonia**	27.37	31.56	13,683 tt	15,778 tt	−13.3	−17.1	−4.5	−1.1
7	7	**Sodium hydroxide**	20.46	18.77	10,230 tt	9,385 tt	9.0	−9.9	−2.0	−0.5
8	8	**Chlorine**	19.92	18.35	9,960 tt	9,176 tt	8.5	−14.8	−2.1	−0.4
9	9	**Phosphoric acid**	19.90	16.52	9,950 tt	8,262 tt	20.4	−16.7	1.2	3.7
10	10	**Sodium carbonate[d]**	16.93	15.64	8,467 tt	7,819 tt	8.3	−5.6	4.6	1.2
11	11	**Nitric acid**	14.75	14.78	7,373 tt	7,390 tt	−0.2	−18.2	−1.5	−1.3
12	14	**Propylene**	13.98	12.54	13,984 mp	12,535 mp	11.6	−7.0	1.4	3.5
13	12	**Ammonium nitrate[e]**	13.24	14.18	6,618 tt	7,091 tt	−6.7	−19.3	−1.7	−0.9
14	13	**Urea[f]**	11.54	13.04	5,770 tt	6,518 tt	−11.5	−19.6	−1.7	5.2
15	16	**Ethylene dichloride**	11.25	7.62	11,247 mp	7,619 mp	47.6	−23.6	0.4	1.9
16	15	**Benzene**	9.48	7.75	1,287 mg	1,052 mg	22.3	−19.5	−2.9	−1.2
17	19	**Ethylbenzene**	7.86	6.66	7,857 mp	6,656 mp	18.0	−14.8	−1.3	3.3
18	18	**Carbon dioxide[g]**	7.15	7.36	3,574 tt	3,682 tt	−2.9	−2.9	2.4	8.6
19	21	**Toluene[h]**	7.12	5.18	981 mg	714 mg	37.4	−16.2	−1.4	0.2
20	20	**Styrene**	6.99	5.94	6,987 mp	5,942 mp	17.6	−11.0	−0.6	1.6
21	24	**Vinyl chloride**	6.95	4.90	6,950 mp	4,902 mp	41.8	−28.7	0.0	2.6
22	17	**Methanol**	6.62	7.56	6,624 mp	7,555 mp	−12.3	−11.9	0.6	−0.6
23	25	**Terephthalic acid[i]**	5.69	4.84	5,688 mp	4,843 mp	17.4	−22.3	−0.9	4.0
24	22	**Ethylene oxide**	5.58	4.99	5,575 mp	4,987 mp	11.8	−2.4	2.2	3.0
25	27	**Xylene**	5.57	4.74	773 mg	658 mg	17.5	−25.3	−1.8	−0.2
26	26	**Formaldehyde[j]**	5.40	4.82	5,398 mp	4,817 mp	12.1	−15.8	−3.3	−1.7
27	23	**Hydrochloric acid**	5.22	4.92	2,608 tt	2,460 tt	6.0	−1.7	−1.3	0.4
28	28	**Ethylene glycol**	4.46	4.31	4,460 mp	4,309 mp	3.5	4.0	2.7	3.1
29	31	***p*-Xylene**	4.11	3.21	4,109 mp	3,207 mp	28.1	−29.2	3.2	5.9
30	30	**Ammonium sulfate**	3.94	3.54	1,968 tt	1,768 tt	11.3	−16.2	0.3	−0.1
31	33	**Cumene**	3.30	2.74	3,304 mp	2,743 mp	20.5	−17.1	−0.5	2.2
32	29	**Potash[k]**	2.87	3.93	1,300 tmt	1,784 tmt	−27.1	−17.3	−10.4	−6.7
33	32	**Acetic acid**	2.79	2.75	2,794 mp	2,748 mp	1.7	−10.6	0.1	1.4
34	37	**Phenol[l]**	2.61	2.02	2,612 mp	2,023 mp	29.1	−21.5	−0.5	1.5
35	35	**Carbon black**	2.50	2.30	2,496 mp	2,302 mp	8.4	−15.7	−5.7	−3.3
36	38	**Butadiene[m]**	2.31	1.92	2,312 mp	1,915 mp	20.7	−35.9	−8.0	−4.4
37	34	**Aluminum sulfate**	2.29	2.37	1,144 tt	1,186 tt	−3.5	−8.3	−2.7	−0.7
38	36	**Acrylonitrile**	2.15	2.04	2,146 mp	2,035 mp	5.5	2.0	4.1	4.7
39	39	**Vinyl acetate**	1.96	1.88	1,962 mp	1,876 mp	4.6	−3.1	3.0	2.7
40	40	**Calcium chloride[n]**	1.88	1.75	942 tt	875 tt	7.7	−20.2	−1.8	−1.4
41	42	**Acetone**	1.87	1.69	1,873 mp	1,694 mp	10.6	−21.0	−5.8	−0.6
42	41	**Sodium sulfate[o]**	1.71	1.73	854 tt	864 tt	−1.2	−25.8	−6.1	−5.1
43	48	**Cyclohexane**	1.69	1.28	1,688 mp	1,275 mp	32.4	−29.9	−6.3	−2.3
44	43	**Propylene oxide**	1.58	1.48	1,581 mp	1,477 mp	7.0	−14.8	−5.0	−1.0
45	46	**Titanium dioxide**	1.51	1.31	757 tt	657 tt	15.2	−13.7	1.5	−0.4
46	45	**Sodium silicate**	1.45	1.33	726 tt	664 tt	9.3	−13.9	−2.6	0.0
47	49	**Adipic acid**	1.42	1.20	1,415 mp	1,197 mp	17.0	−1.1	−2.9	−1.1
48	47	**Sodium tripolyphosphate**	1.34	1.30	669 tt	651 tt	2.8	−6.5	−2.0	−3.6
49	44	**Isopropyl alcohol**	1.21	1.38	1,212 mp	1,380 mp	−12.2	−17.3	−6.9	−4.1
50	50	**Ethanol**	1.10	1.02	1,104 mp	1,023 mp	7.9	−22.3	−2.7	−5.6
TOTAL ORGANICS			**165.17**	**143.96**			**14.7%**	**−17.9%**	**−0.1%**	**1.5%**
TOTAL INORGANICS			**333.41**	**319.04**			**4.5%**	**−15.6%**	**−1.5%**	**0.7%**
GRAND TOTAL			**498.58**	**463.00**			**7.7%**	**−16.3%**	**−1.0%**	**0.9%**

a Revised. **b** tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons, tmt = thousands of metric tons. **c** Except refractory dolomite. **d** Synthetic and natural. **e** Original solution. **f** 100% basis. **g** Liquid and solid only. **h** All grades. **i** Includes both acid and ester without double counting. **j** 37% by weight. **k** K_2O basis. **l** Synthetic only. **m** Rubber grade. **n** Solid and liquid. **o** High and low purity. **Sources:** Bureau of the Census, Bureau of Mines, International Trade Commission, C&EN estimates

PRODUCTION: Chemical industry last year returned to 1981 levels

Industrial production indexes, 1967 = 100	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	Annual change	
												1982–83	1973–83
Total index	147.6	138.6	151.0	147.0	152.5	146.1	138.2	130.5	117.8	129.3	129.8	6%	1%
Manufacturing, total	148.2	137.6	150.4	146.7	153.6	146.8	138.4	130.3	116.3	129.4	129.8	8	1
Nondurable manufacturing	168.1	156.2	164.8	161.2	164.0	156.9	150.5	141.8	126.4	134.6	133.8	8	2
Chemicals and products	215.0	196.1	215.6	207.1	211.8	197.4	185.7	170.9	147.2	159.4	154.5	10	3
Chemicals and synthetic materials	226.2	196.7	228.6	222.2	234.2	216.7	201.1	185.1	154.1	176.7	171.9	15	3
Basic chemicals	175.2	157.1	186.8	187.4	192.0	181.9	171.8	161.8	135.9	153.3	147.7	12	2
Alkalies and chlorine	108.5	99.2	114.7	121.4	132.3	119.7	119.2	119.0	106.5	125.6	123.8	9	−1
Gases, coal tar, inorganic pigments	177.4	160.0	181.5	184.3	197.7	186.0	174.3	164.4	133.3	165.0	157.8	11	1
Basic organic chemicals	220.9	192.9	236.7	231.6	233.3	221.2	204.7	189.8	155.3	177.9	170.0	15	3
Inorganic chemicals, nec	114.4	109.9	125.5	132.4	134.9	129.3	128.5	124.3	112.9	112.6	110.8	4	−1
Acids and fertilizer materials	121.2	116.0	137.2	145.9	142.0	133.6	124.2	117.6	108.4	116.6	113.1	4	1
Synthetic materials	330.3	277.4	313.7	293.3	320.1	287.6	260.8	232.5	191.0	224.4	221.1	19	4
Plastics materials	486.0	403.6	429.3	386.5	420.1	366.5	320.3	280.1	213.1	258.5	243.3	20	7
Synthetic rubber	109.2	84.9	103.3	103.2	130.5	127.5	124.5	118.7	101.2	129.7	135.6	29	−2
Man-made fibers	236.2	204.2	254.4	250.3	270.8	250.9	236.8	214.3	191.2	214.4	220.1	16	1
Chemical products	204.0	195.8	203.0	192.4	190.2	179.0	170.9	157.2	140.7	142.8	137.7	4	4
Drugs and medicines	280.6	266.8	267.1	245.7	238.2	220.6	213.9	191.5	174.1	179.6	170.1	5	5
Soap and toiletries	179.1	171.5	177.0	170.8	171.6	163.8	155.0	143.0	127.7	128.1	129.0	4	3
Paints	118.3	115.3	127.4	130.5	137.8	132.6	125.8	122.8	114.2	119.2	114.7	3	0
Agricultural chemicals	197.3	208.7	241.4	230.5	221.6	211.8	201.1	185.4	163.9	144.6	127.0	−5	5
Petroleum products	120.3	121.8	129.7	132.9	143.9	145.2	142.6	133.5	124.1	124.7	128.5	−1	−1
Rubber and plastics products	291.9	254.7	274.0	255.7	272.2	253.6	232.3	199.7	166.7	195.2	184.1	15	5

nec = not elsewhere classified. **Source:** Federal Reserve Board

MINERALS: Production of fertilizer raw materials recovered somewhat in 1983

Thousands of tons	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	Annual change	
												1982–83	1973–83
Bromine, sold or used[a]	190[b]	200	189	189	249	223	217	230	204	216	209	−5%	−1%
Calcium chloride, production[c,d]	912[b]	853	917	811	981	1,031	968	897	828	1,101	858	7	1
Iodine, consumption[e,f]	3.6[b]	3.4	4.4	4.4	4.4	4.0	4.3	3.6	3.1	3.8	3.5	6	0
Imports[f]	2.5[b]	2.3	3.0	3.1	3.1	3.4	3.5	3.2	2.7	4.0	3.1	9	−2
Lime, sold or used[g]	14,719[b]	14,112	18,890	19,037	20,983	20,484	19,987	20,257	19,159	21,645	21,132	4	−4
Lithium, consumption[e,h]	2.2[b]	2.0	3.2	3.0	3.2	3.4	4.1	2.8	2.9	3.8	3.2	10	−4
Phosphate rock													
Marketable production	46,928	41,241	59,110	59,982	56,891	55,156	52,091	49,231	48,806	45,676	42,128	14	1
Exports	13,239	10,849	11,458	15,737	15,827	14,187	14,584	10,398	12,270	13,895	13,873	22	−1
Potash (K_2O equivalent)[i]													
Production	1,433[b]	1,967	2,377	2,468	2,453	2,484	2,457	2,400	2,501	2,552	2,604	−27	−6
Imports[j]	4,630[b]	4,253	5,287	5,481	5,693	5,189	5,076	4,594	3,797	4,325	3,587	9	3
Apparent consumption	5,699[b]	5,647	6,849	6,999	7,620	6,840	6,605	6,149	5,113	6,086	5,563	1	0
Salt, total sold or used[k]	31,500[b]	37,880	38,915	40,396	45,820	42,896	43,439	44,218	41,057	46,565	43,939	−17	−3
Evaporated	5,040[b]	5,303	6,209	6,358	6,248	5,872	5,704	5,634	5,372	5,951	5,913	−5	−2
Rock	11,340[b]	12,879	11,871	11,806	14,891	14,688	14,958	15,668	14,283	14,835	12,347	−12	−1
Salt in brine[l]	15,120[b]	19,698	20,835	22,231	24,681	22,336	22,777	22,917	21,401	25,779	25,680	−23	−5
Sodium carbonate, production[d]	8,400[b]	7,819	8,281	8,275	8,253	8,290	8,040	7,560	7,130	7,566	7,535	7	1
Sulfur, production[m]	10,240	10,788	13,388	13,080	13,339	12,318	11,824	11,992	12,610	12,789	12,231	−5	−2
Apparent consumption[n]	12,112	11,088	14,093	15,056	15,145	13,889	12,850	12,060	11,875	12,115	11,463	9	1
Frasch, production	3,530	4,641	6,997	7,044	7,007	6,226	6,520	7,016	8,077	8,849	8,518	−24	−8
Recovered elemental, production	5,462	4,855	4,695	4,490	4,486	4,478	3,995	3,514	3,326	2,948	2,706	13	7
Other, production	1,249	1,293	1,695	1,547	1,845	1,615	1,310	1,462	1,208	992	1,008	−3	2

a Elemental bromine sold as such or used in preparation of bromine compounds by primary producers. **b** Preliminary figure. **c** 75% $CaCl_2$ equivalent. **d** Natural and synthetic. **e** Estimated apparent consumption. **f** Crude elemental iodine. **g** Includes Puerto Rican production. **h** Lithium content basis. **i** Includes muriate and sulfate of potash, potassium magnesium sulfate, and parent salts; excludes other chemical compounds containing potassium. **j** Includes nitrate of potash. **k** Total obtained by all recovery methods that was sold or used by domestic producers (figures differ slightly from U.S. production figures); figures for 1973–81 include Puerto Rican production. **l** Sold or used as such. **m** Sulfur content basis. **n** Calculated from shipments plus imports minus exports (sulfur content basis). **Source:** Bureau of Mines

ORGANIC CHEMICALS: Output of most products increased, reversing 1982 trend

Millions of lb unless otherwise noted	Production											Annual change	
	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1982–83	1973–83
Acetic acid, synthetic	2,794	2,748	2,705	2,977	3,265	2,776	2,570	2,463	2,197	2,584	2,429	2%	1%
Acetone	1,873	1,694	2,144	2,076	2,653	2,519	2,219	1,869	1,640	1,980	1,989	11	−1
Acrylonitrile	2,146	2,035	1,997	1,830	2,018	1,752	1,646	1,518	1,215	1,412	1,354	5	5
Aniline	665	557	634	659	690	606	584	544	407	551	458	19	4
Benzene, mg[b,c]	1,287	1,069	1,339	1,585	1,673	1,488	1,457	1,425	1,024	1,488	1,453	20	−1
Bisphenol A	643	480	555	530	576	471	455	449	293	370	320	34	7
1,3-Butadiene[d]	2,312	1,915	2,986	2,799	3,583	3,515	3,259	3,507	2,597	3,682	3,644	21	−4
Butanol	801	730	809	790	766	756	660	625	490	558	519	10	4
Caprolactam	979	793	928	905[e]	945	919	867	780	713	668	656	23	4
Carbon disulfide	na	261	388	377	448	476	505	508	479	782	777	na	na
Carbon tetrachloride	573	587	726	710	714	737	809	857	906	1,163	1,047	−2	−6
Chloroform	351	299	405	273	356	349	302	292	262	302	253	17	3
Cumene	3,304	2,743	3,309	3,459	3,917	3,380	2,644	2,716	2,003	2,906	2,665	20	2
Cyclohexane	1,688	1,275	1,820	1,964	2,425	2,332	2,265	2,187	1,734	2,352	2,123	32	−2
Dioctyl phthalates	288	266	304	353	336	409	400	413	312	395	429	8	−4
Dodecylbenzene[f]	na	509	535	563[e]	627	526	526	529	495	533	498	na	na
Ethanol, synthetic	1,103	1,023	1,317	1,451	1,408	1,267	1,339	1,496	1,429	1,618	1,962	8	−6
Ethanolamines[g]	469	416	429	376	420	362	308	286	258	307	293	13	5
Ethyl chloride	282	339	324	396	582	540	612	669	575	662	660	−17	−8
Ethylbenzene	7,857	6,656	7,813	7,642	8,448	8,385	8,312	5,770	4,822	6,048	5,688	18	3
Ethylene	28,586	24,501	29,418	28,667	29,904	25,955	25,172	22,475	20,499	23,891	22,329	17	3
Ethylene dichloride	11,247	7,619	9,974	11,108	11,794	11,001	10,997	8,042	7,977	9,165[h]	9,293[h]	48	2
Ethylene glycol	4,460	4,309	4,143	4,386	4,729	3,904	3,675	3,335	3,809	3,341	3,278	4	3
Ethylene oxide	5,575	4,987	4,937	5,220	5,665	5,012	4,364	4,184	4,467	4,200[i]	4,167	12	3
2-Ethylhexanol	387	325	389	367	318	420	493	450	387	395	402	19	0
Formaldehyde, 37%[j]	5,398	4,817	5,721	5,555	5,971	6,381	6,046	5,449	4,558	5,764	6,424	12	−2
Isopropyl alcohol	1,212	1,380	1,669	1,836	1,900	1,730	1,888	1,936	1,521	1,939	1,835	−12	−4
Maleic anhydride	302	260	293	304	323	341	294	264	216	290	282	16	1
Methanol, synthetic	6,624	7,555	8,577	7,153	7,367	6,443	6,453	6,242	5,176	6,878	7,064	−12	−1
Methyl chloride	396	366	405	362	463	454	476	378	366	493[h]	544[h]	8	−3
Methyl ethyl ketone	535	468	611	587	656	661	512	428	425	506	541	14	0
Methyl chloroform	586	595	614	692	716	644	635	631	459	592	548	−2	1
Methylene chloride	530	532	592	564	633	570	478	538	497	609	520	0	0
Perchloroethylene	508	585	691	765	773	725	614	669	679	734	706	−13	−3
Phenol, synthetic[k]	2,612	2,023	2,578	2,568	2,981	2,682	2,338	2,121	1,746	2,298	2,241	29	2
Phthalic anhydride	851	684	870	818	1,013	978	926	902	702	977	1,023	24	−2
Propylene[c]	13,894	12,535[l]	13,482[l]	13,676[l]	14,198[l]	13,014[l]	13,328[l]	10,030[l]	8,709[l]	10,475[m]	9,884[m]	11	3
Propylene glycol	481	400	473	488	610	547	489	517	391	510	502	20	0
Styrene, monomer	6,987	5,942	6,679	6,856	7,484	7,186	6,867	6,301	4,673	5,956	5,975	18	2
Terephthalic acid, dimethyl ester[n]	5,688	4,843	6,235	6,054	6,159	5,954	5,410	5,051	4,614	4,262	2,564[o]	17	8
Toluene, mg[b,c]	981	715	856	1,017	1,010	1,054	1,018	999	705	922	958	37	0
Vinyl acetate	1,962	1,876	1,936	1,922	1,982	1,692	1,586	1,481	1,290	1,403	1,503	5	3
Vinyl chloride	6,950	4,902	6,874	6,466	6,389	6,941	5,986	5,677	4,196	5,621	5,351	42	3
***o*-Xylene**	774	802	918	995	1,082	1,013	985	854	703	1,056	1,068	−3	−3
***p*-Xylene**	4,109	3,391	4,532	4,238	4,650	3,516	3,172	2,911	2,484	2,707	2,326	21	6

a Preliminary. **b** Tar distillers not included; includes material for use in blending motor fuels. **c** All grades. **d** Rubber grade. **e** Preliminary figure; final figure not available. **f** Includes straight-chain dodecylbenzene, tridecylbenzene, and other straight-chain alkylbenzenes. **g** Mono-, di-, and triethanolamines. **h** Production figure may be too low, because some methyl chloride and ethylene dichloride were produced but not separated or measured accurately by some producers. **i** Approximate. **j** By weight. **k** Does not include data for coke ovens and gas retort ovens. **l** Includes refinery propylene. **m** Includes data for propane-propylene mixture. **n** Includes both acid and dimethyl ester (DMT), without double counting. **o** Includes only dimethyl ester. **mg** = millions of gallons. **na** = not available. **Source:** International Trade Commission

INORGANICS: Production of most chemicals recovered from 1982 lows

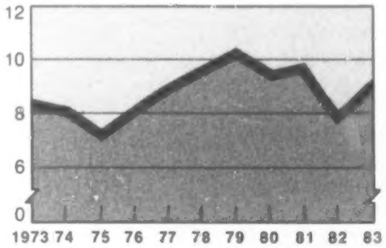
Thousands of tons unless otherwise noted	Production											Annual change	
	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1982–83	1973–83
Aluminum sulfate[b]	1,144	1,154	1,294	1,286	1,315	1,309	1,255	1,202	1,146	1,257	1,233	−1%	−1%
Ammonia,[c,d] 100%	13,683	15,776	19,044	19,653	18,634	17,119	17,765	16,716	16,419	15,733	15,208	−13	−1
Ammonium nitrate,[e] 100%	6,618	7,091	8,861	9,128	8,293	7,210	7,177	7,186	7,088	7,542	7,235	−7	−1
Ammonium sulfate,[d,f] 100%	1,968	1,768	2,185	2,136	2,363	2,449	2,264	2,010	2,106	2,120	1,987	11	0
Chlorine gas[g]	9,960	9,176	10,763	11,421	12,291	11,052	10,573	10,378	9,167	10,753	10,402	9	0
Hydrochloric acid,[h] 100%	2,608	2,460	2,574	2,888	3,090	2,793	2,668	2,542	2,009	2,470	2,534	6	0
Hydrogen,[i,j] bcf, 100%	104	89	105	107	106	90	85	82	74	82	65	17	5
Nitric acid,[k] 100%	7,373	7,390	9,093	9,231	8,916	7,934	7,987	7,791	7,527	8,120	8,398	−0	−1
Nitrogen gas,[i,l] bcf, 100%	580	484	490	479	427	379	328	289	252	243	227	20	10
Oxygen,[i,l] bcf, 100%	347	349	431	431	456	430	392	388	353	390	389	−1	−1
Phosphoric acid, 100% P_2O_5	9,950	8,262	9,958	10,848	10,318	9,637	8,745	7,949	7,677	7,213	6,927	20	2
Phosphorus[m]	366	361	426	432	460	441	430	437	450	524	526	1	−4
Sodium chlorate, 100%	229	251	297	312	269	265	251	199	173	203	204	−9	1
Sodium hydroxide, 100%	10,230	9,385	10,621	11,625	12,759	11,309	11,000	10,516	9,635	11,189	10,734	9	−0
Sodium phosphate[n]	669	651	696	727	757	739	717	724	770	903	967	3	−4
Sodium silicate[o]	731	664	771	805	813	829	760	747	724	770	723	10	0
Sodium sulfate,[p] 100%	855	864	1,111	1,140	1,121	1,174	1,199	1,232	1,227	1,348	1,437	−1	−5
Sulfuric acid,[q] 100%	34,725	32,680	40,742	44,158	43,204	41,314	38,337	34,878	32,360	33,936	31,949	6	1
Titanium dioxide,[r] 100%	757	657	761	727	742	701	687	713	603	787	785	15	0
Urea, 100%	5,770	6,518	8,062	7,830	7,000	6,273	5,072	4,498	3,799	3,789	3,543	−11	5

a Preliminary. **b** Commercial, 17% Al_2O_3; includes municipalities. **c** Synthetic anhydrous. **d** Excludes by-product ammonia liquor and ammonium sulfate. **e** Original solution. **f** Synthetic and noncoke by-product. **g** Includes quantities liquefied for use, storage, or shipment. **h** Includes anhydrous hydrochloric acid production. **i** High- and low-purity gas. **j** Liquid and gas; excludes amounts vented and used as fuel, and amounts produced in petroleum refineries for captive use. **k** Includes unspecified amounts of nitric acid produced but not withdrawn from the system. **l** Excludes amounts produced and consumed in making synthetic ammonia or ammonia derivatives. **m** Elemental, white (yellow), and red. **n** Tripolyphosphate (100% $Na_5P_3O_{10}$). **o** Soluble silicate glass (water glass), solid and liquid (anhydrous); excludes amounts produced and consumed in making meta-, ortho-, and sesquisilicates. **p** Anhydrous, high and low purity, and Glauber's salt. **q** Gross (new and fortified). **r** Composite and pure. **Note:** bcf = billions of cubic feet. **Sources:** Department of Commerce, International Trade Commission

MAN-MADE FIBERS: Production was up in 1983, but remained well below earlier peak

Man-made fibers production

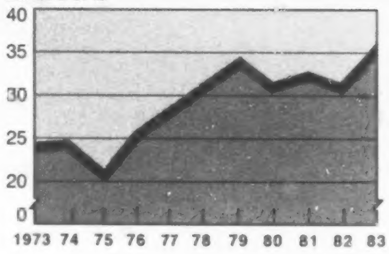
Billions of lb



Millions of lb	Production											Annual change	
	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1982–83	1973–83
CELLULOSIC FIBERS													
Acetate[a]	229	196	261	316	324	308	290	298	313	382	462	−17%	−7%
Rayon	401	388	509	490	606	597	598	543	436	817	895	3	−8
NONCELLULOSIC FIBERS													
Acrylic[b]	671	624	691	779	761	726	709	621	525	631	742	7	−1
Nylon[c]	2419	1927	2332	2358	2,720	2550	2326	2075	1857	2124	2175	26	1
Olefins[d]	906	723	785	748	759	692	635	577	497	531	492	25	6
Polyester	3544	3169	4176	3989	4,178	3800	3642	3340	2995	2926	2888	12	2
Textile glass	1168	899	1041	867	1,014	923	787	676	546	683	688	30	5
TOTAL	**9336**	**7926**	**9795**	**9547**	**10,362**	**9596**	**8987**	**8130**	**7169**	**8094**	**8342**	**18%**	**1%**

a Includes diacetate and triacetate; excludes production for cigarette filtration. **b** Includes modacrylic. **c** Includes aramid. **d** Includes olefin yarn and monofilaments, and olefin and vinyon staple and tow. **Note:** Totals may not add because of rounding. **Source:** Textile Economics Bureau

Plastics production



PLASTICS: Production in 1983 surged to a new high

Millions of lb[a]	Production											Annual change	
	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1982–83	1973–83
THERMOSETTING RESINS													
Epoxy[b]	334	286	336	315	361	299	261	244	198	249	223	17%	4%
Polyester[c]	1,084	865	997	947	1,147	1,209	1,061	1,042	834	911	1,051	25	0
Urea	1,172	998	1,165	1,165	1,367	1,122	963	821	690	835	867	17	3
Melamine	180	158	179	167	200	202	200	186	115	164	170	14	1
Phenolic[d]	2,477[e]	2,006[e]	2,333[e]	1,499	1,781	1,617	1,458	1,340	1,051	1,335	1,387	23	nc
TOTAL	**5,247**	**4,313**	**5,010**	**4,093**	**4,856**	**4,449**	**3,943**	**3,633**	**2,888**	**3,494**	**3,698**	**22%**	nc
THERMOPLASTIC RESINS													
Polyethylene													
Low density[f]	8,041	7,503	7,693	7,291	7,793	7,111	6,471	5,813	4,743	5,973	5,803	7	3
High density[g]	5,689	4,928	4,695	4,405	5,010	4,201	3,652	3,125	2,468	2,837	2,637	15	8
Polypropylene	4,433	3,477	3,955	3,648	3,841	3,074	2,747	2,632	1,902	2,249	2,162	27	7
Styrene-acrylonitrile	93	91	107	111	124	120	115	113	109	109	121	2	−3
Polystyrene	3,570	3,191	3,621	3,521	4,005	3,823	3,446	3,195	2,662	3,364	3,322	12	1
Styrene-butadiene copolymers, acrylonitrile-butadiene-styrene, and other styrene polymers	1,889	1,380	1,745	1,705	2,107	2,012	1,882	1,744	1,227	1,536	1,580	37	2
Polyamide, nylon type	321	228	312	274	327	275	254	247	135	204	205	41	5
Polyvinyl chloride and copolymers	6,067	5,326	5,707	5,470	6,119	5,723	5,253	4,716	3,648	4,850	4,562	14	3
Other vinyl resins[h]	186	177	208	196	220	197	197	225	187	209	199	5	−1
TOTAL	**30,289**	**26,301**	**28,043**	**26,621**	**29,546**	**26,536**	**24,017**	**21,810**	**17,081**	**21,331**	**20,591**	15%	4%

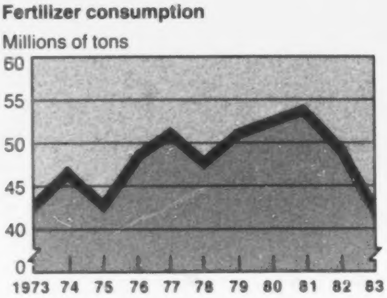
a Dry-weight basis, unless otherwise specified. **b** Unmodified. **c** Unsaturated. **d** Includes other tar acid resins. **e** Gross weight basis. **f** 0.940 density and below. **g** Density above 0.940. **h** Includes polyvinyl butyral, polyvinyl formal, and polyvinylidene chloride. **nc** = not comparable. **Source:** Society of the Plastics Industry

SYNTHETIC RUBBER: Production expanded in 1983, but not to levels of 1970s

Thousands of metric tons	Production											Annual change	
	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1982–83	1973–83
Styrene-butadiene rubber[a]	904	876	1032	1074	1378	1395	1395	1333	1179	1466	1537	3%	−5%
Polybutadiene	333	288	342	311	397	378	361	352	290	310	337	16	0
Nitrile	55	45	66	63	75	73	70	73	55	88	84	22	−4
Ethylene-propylene	175	123	178	144	175	174	158	130	84	126	120	42	4
Polychloroprene	115	119	143	151	183	161	165	165	144	163	na	−3	na
Other[b]	396[c]	379[c]	261	272	326	292	267	250	188	345	549[d]	4	na
TOTAL	**1978**	**1830**	**2022**	**2015**	**2534**	**2473**	**2416**	**2303**	**1940**	**2498**	**2627**	8%	−3%

a Excludes high-styrene latex (more than 45% styrene). **b** Includes butyl, polyisoprene, silicone, and other synthetic elastomers. Excludes polyurethane rubber. **c** Values are partly estimated. **d** Includes polychloroprene. **na** = not available. **Source:** Rubber Manufacturers Association

FERTILIZERS: U.S. production continued in the doldrums last year



Fertilizer consumption

Note: Years ending June 30.
Source: Department of Agriculture

Thousands of tons	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	Annual change 1982–83	Annual change 1973–83
NITROGEN (N)													
Domestic production	9,855	11,598	13,036	12,323	11,106	10,466	10,789	10,572	9343	10,094	9447	−15%	0%
Imports	2,654	2,531	2,455	2,566	2,165	1,866	1,842	1,218	1198	1,068	882	5	12
Exports	2,074	2,499	3,088	2,641	2,468	1,778	1,251	1,239	1115	1,269	1508	−17	3
Domestic supply	10,435	11,630	12,403	12,248	10,803	10,554	11,380	10,551	9426	9,893	8821	−10	2
PHOSPHATE (P_2O_5)													
Domestic production	8,043	7,818	10,471	10,012	9,432	8,245	7,793	7,199	7230	6,869	6387	3	2
Imports	133	193	250	239	236	229	245	221	274	315	312	−31	−8
Exports	3,916	3,751	4,381	3,925	3,848	3,290	2,501	2,175	1860	1,581	1422	4	11
Domestic supply	4,260	4,260	6,340	6,326	5,820	5,184	5,537	5,245	5644	5,603	5277	0	−2
POTASH (K_2O)													
Domestic production	1,859	1,831	2,262	2,474	2,519	2,176	2,584	2,313	2287	2,604	2690	2	−4
Imports	4,402	4,797	5,487	5,403	5,085	4,948	4,955	3,910	3847	4,114	3192	−8	3
Exports	624	641	876	1,048	999	1,003	994	911	848	947	922	−3	−4
Domestic supply	5,637	5,987	6,873	6,829	6,605	6,121	6,545	5,312	5286	5,771	4960	−6	1

U.S. fertilizer consumption fell for the second year in a row

	Consumption											Annual change	
Thousands of tons	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1982–83	1973–83
TYPE													
Mixed fertilizer[a]	18,800	20,815	23,525	23,270	23,742	22,110	24,099	22,958	20,647	24,067	22,547	−10%	−2%
Primary nutrient material[b]	23,500	27,918	30,463	27,221	25,600	23,511	24,999	23,935	19,959	20,897	19,275	−16	1
Secondary and micronutrients[c]	—	—	—	2,296	2,139	1,877	2,525	2,296	1,878	2,130	1,466	—	
TOTAL	**42,300**	**48,733**	**53,988**	**52,787**	**51,481**	**47,497**	**51,624**	**49,189**	**42,484**	**47,094**	**43,288**	−13%	−0%
PRIMARY NUTRIENT CONTENT													
Nitrogen (N)	9,185	10,974	11,924	11,407	10,715	9,965	10,647	10,412	8,601	9,157	8,295	−16	1
Phosphate (P_2O_5)	4,160	4,810	5,434	5,432	5,606	5,096	5,630	5,228	4,507	5,099	5,085	−14	−2
Potash (K_2O)	4,842	5,623	6,320	6,245	6,244	5,526	5,834	5,210	4,453	5,083	4,649	−14	0
TOTAL	**18,187**	**21,407**	**23,678**	**23,083**	**22,565**	**20,587**	**22,111**	**20,849**	**17,561**	**19,338**	**18,029**	−15%	0%

[a] Fertilizers that contain more than one primary nutrient. [b] Fertilizer materials that contain one primary nutrient. [c] Included in primary nutrient material in 1981–83. **Note:** Years ending June 30. **Source:** Department of Agriculture

NITROGEN OUTPUT: Dropped steeply in 1983

Thousands of tons (N)	1983	1982	1981	1973	Change 1982–83
Ammonia[a]	3587	5,032	5,455	3835	−29%
Ammonium nitrate[b,c]	943	1,105	1,225	1360	−15
Urea	1692	1,684	1,704	576	0
Ammonium sulfate[c]	395	432	555	500	−9
All other	3238	3,345	4,097	3179	−3
TOTAL	**9855**	**11,598**	**13,036**	**9450**	−15%

[a] Includes aqueous solutions. [b] Includes ammonium nitrate-limestone mixtures. [c] Adjusted for estimated quantity going into nonfertilizer uses. **Note:** Years ending June 30. **Source:** Department of Agriculture

PHOSPHATE OUTPUT: Recovered a bit

Thousands of tons (P_2O_5)	1983	1982	1981	1973	Change 1982–83
Ammonium phosphate[a]	5026	4434	6,015	2704	13%
Concentrated superphosphate	1184	1151	1,713	1666	3
Normal and enriched superphosphate	110	153	357	620	−28
All other	1723	2080	2,386	1397	−17
TOTAL	**8043**	**7818**	**10,471**	**6387**	3%

[a] Liquid and solid, excluding that combined with potash salts in process of manufacture. **Note:** Years ending June 30. **Source:** Department of Agriculture

Earnings rise but profitability is still low

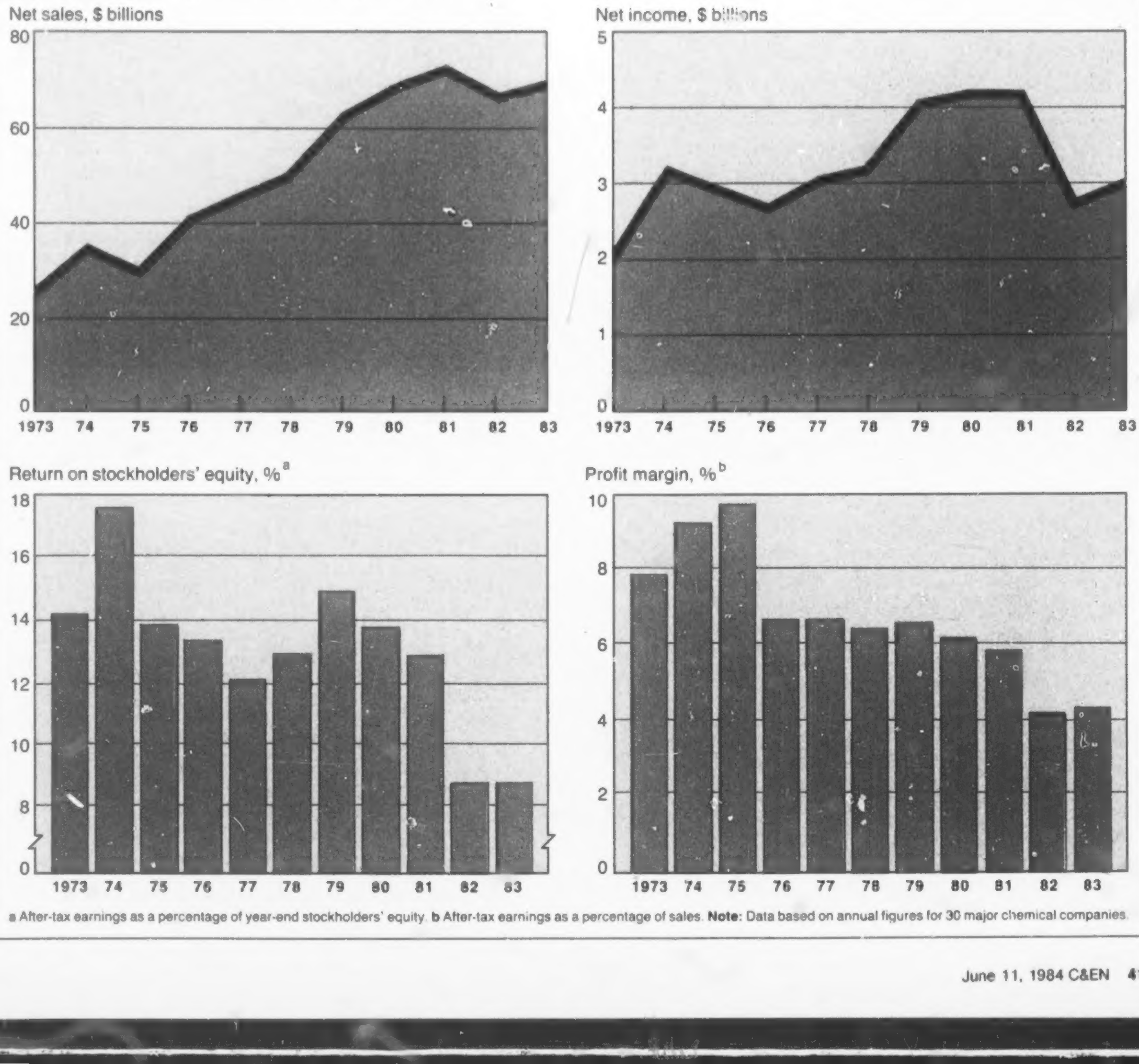
For the U.S. chemical industry, 1983 brought a climb from the depths of the recession. The year, if represented on a graph, is a slope upward for sales, profits, profitability, and production. The only laggard is pricing, which is still eliciting complaints from many chemical executives.

However, viewed as a whole, the year for the chemical industry was fairly flat. Sales increased just 5% to a total of $69.3 billion for a sample of 30 leading chemical companies. Profits at these companies increased 11% from the year before to $3.0 billion.

As a result, profit margins for the sample managed to climb to 4.3% in 1983 from 4.1% the year before. This is still well below the profit margin for the firms in 1981 of 5.8% and less than half the more than 9% the industry was earning on sales in 1974 and 1975.

While profit margins were climbing slightly, return on year-end stockholders' equity was going nowhere. Average return for the 30 companies in 1983 was 8.8%, the same as in 1982. Again, return on equity continues well down from returns in the teens that had been common in the past decade.

Chemical producers' sales and earnings both recovered last year, but not to previous peak, and profitability remained depressed



a After-tax earnings as a percentage of year-end stockholders' equity. b After-tax earnings as a percentage of sales. **Note:** Data based on annual figures for 30 major chemical companies.

TOP 100 CHEMICAL PRODUCERS: For only half of these companies do sales of chemicals account

Rank 1983	Rank 1982[a]	Company	Chemical sales 1983 ($ millions)	Change from 1982	Chemical sales as % of total sales	Industry classification	Chemical operating profit 1983[b] ($ millions)	Change from 1982	Chemical operating profits as % of total operating profit	Operating profit margin[c]	Chemical assets 1983 ($ millions)	Chemical assets as % of total assets	Operating return on chemical assets[d]
1	1	**Du Pont**	$11,607	6.4%	32.8%	Diversified	$1144	171.7%	26.2%	9.9%	$7591	31.1%	15.1%
2	2	**Dow Chemical**	8,875	8.1	81.0	Basic chemicals	573	153.5	111.0	6.5	8193	68.4	7.0
3	3	**Exxon**	8,439	39.5	7.5	Petroleum	348	640.4	3.9	4.1	4852	7.9	7.2
4	4	**Monsanto**	5,771[e]	11.8	92.6	Basic chemicals	568	8.4	102.3	9.8	4498	70.0	12.6
5	5	**Union Carbide**	3,912	−2.5	43.5	Basic chemicals	275	100.7	40.6	7.3	4917	47.8	5.6
6	7	**Celanese**	3,261	6.5	100.0	Basic chemicals	214	448.7	100.0	6.6	2869	100.0	7.5
7	6	**Shell Oil**	3,227	4.6	16.4	Petroleum	130	def	4.2	4.0	3759	17.0	3.5
8	8	**Standard Oil (Ind.)**	2,906	4.3	9.9	Petroleum	173	30.1	4.8	6.0	2445	9.6	7.1
9	9	**W. R. Grace**	2,760	5.3	44.4	Specialty chemicals	324	3.5	62.3	11.7	1641	32.6	19.7
10	11	**Atlantic Richfield**	2,550	13.8	9.8	Petroleum	64	def	2.4	2.5	2603	11.2	2.5
11	14	**Allied**	2,337	9.1	23.3	Diversified	224	69.7	20.3	9.6	1299	17.0	17.2
12	13	**Mobil**	2,331	8.5	4.0	Petroleum	−16	def	def	def	2266	6.5	def
13	12	**Eastman Kodak**	2,285	6.2	22.5	Photo equipment	214	4.4	20.8	9.4	2124	19.4	10.1
14	10	**Phillips Petroleum**	2,255	−4.3	14.8	Petroleum	83	260.9	3.2	3.7	1413	10.8	5.9
15	15	**Hercules**	2,007	−1.6	76.3	Basic chemicals	121	61.3	66.1	6.0	1204	55.4	10.0
16	17	**Rohm & Haas**	1,808	4.7	96.4	Basic chemicals	298	91.0	108.8	16.5	1038	68.7	28.7
17	16	**Gulf Oil**	1,748	−12.9	6.2	Petroleum	−76	def	def	def	1009	4.8	def
18	18	**American Cyanamid**	1,719	1.3	48.6	Basic chemicals	106	6.0	36.5	6.2	1275	41.7	8.3
19	20	**Ethyl**	1,478[e]	4.7	84.7	Basic chemicals	156	2.6	84.1	10.6	901	83.4	17.3
20	21	**Air Products**[f]	1,412	3.9	86.4	Basic chemicals	196	2.4	96.2	13.9	1654	74.5	11.8
21	19	**Stauffer Chemical**	1,340	nm	100.0	Basic chemicals	−14	def	def	def	2048	100.0	def
22	30	**Mobay**	1,300	15.0	100.0	Basic chemicals	66[g]	def	100.0	5.1	na	na	na
23	22	**FMC**	1,296	−1.8	37.0	Machinery	169	13.3	61.3	13.0	1063	38.2	15.9
24	25	**Borden**	1,295[e]	6.2	30.4	Dairy products	138	60.9	37.3	10.6	1325	48.7	10.4
25	23	**Ciba-Geigy**	1,290	0.3	65.1	Specialty chemicals	na	na	na	na	na	na	na
26	28	**American Hoechst**	1,222[e]	3.0	75.2	Basic chemicals	na	na	na	na	na	na	na
27	27	**Ashland Oil**	1,208	0.9	14.9	Petroleum	1	−96.4	0.5	0.1	423	10.3	0.2
28	40	**Occidental Petroleum**	1,137[h]	−10.1	5.8	Petroleum	−12	def	def	def	985	8.4	def
28	26	**Texaco**	1,137	−6.1	2.8	Petroleum	−65	def	def	def	895	3.3	def
30	34	**B. F. Goodrich**	1,133	11.6	35.5	Rubber products	44	3927.3	43.9	3.9	1214	47.1	3.6
30	29	**Unocal Corp.**	1,133	−1.7	10.7	Petroleum	74[g]	−17.3	11.8	6.5	699	7.6	10.6
32	31	**U.S. Steel**	1,128	4.7	6.4	Steel	−27	def	def	def	1130	5.9	def
33	36	**Olin**	1,111	9.7	57.4	Basic chemicals	68	21.5	44.9	6.1	1002	54.8	6.8
34	32	**Standard Oil of Calif.**	1,059	1.1	3.7	Petroleum	−12[g]	def	def	def	780	3.8	def
35	38	**BASF Wyandotte**	1,034	15.6	100.0	Basic chemicals	20	def	100.0	1.9	726	100.0	2.7
36	35	**International Minerals**[i]	997	−1.6	68.2	Agrichemicals	156	−7.6	81.1	15.7	1377	70.8	11.4
37	33	**Diamond Shamrock**	942	−9.0	23.4	Petroleum	12	−83.2	def	1.3	1063	17.6	1.1
38	39	**PPG Industries**	882	−1.2	24.0	Glass products	51	30.8	11.8	5.8	1152	31.9	4.4
39	37	**CF Industries**	862[e]	−6.2	100.0	Agrichemicals	34	def	100.0	4.0	1013	100.0	3.4
40	52	**Borg-Warner**	826	34.8	23.5	Auto equipment	110	112.7	35.2	13.3	365	13.9	30.2
41	41	**Lubrizol**	800	−1.5	100.0	Specialty chemicals	109	5.1	100.0	13.6	683	100.0	15.9
42	44	**National Distillers**	785	14.6	30.3	Alcoholic beverages	68	86.5	41.6	8.6	683	34.6	9.9
43	46	**Dow Corning**	763	15.1	100.0	Specialty chemicals	68[g]	29.1	100.0	9.0	na	na	na
44	43	**Reichhold Chemicals**	747	−5.0	100.0	Basic chemicals	35	137.9	100.0	4.6	371	96.4	9.3
45	40	**Williams Cos.**	740	−10.7	34.1	Agrichemicals	1	def	0.6	0.1	894	19.1	0.1
46	42	**Eli Lilly**	727	−7.8	24.0	Drugs	98	−33.4	12.4	13.5	793	837.8	12.3
47	51	**Georgia-Pacific**	683	8.8	10.6	Wood products	64	−16.9	61.0	9.4	1023	20.5	6.3
48	57	**Badische**	671	33.9	100.0	Basic chemicals	30	def	100.0	4.4	513	100.0	5.7
49	47	**Nalco Chemical**	659	2.4	100.0	Specialty chemicals	118	19.0	100.0	17.8	489	100.0	24.0
50	49	**Merck**	606	−5.1	18.7	Drugs	52	−11.7	7.3	8.6	592	14.0	8.8

a Revised. b Operating profit defined as sales less administrative expense and cost of sales. c Operating profit from chemicals as a percentage of chemical sales. d Operating profit as a percentage of identifiable chemical assets. e Chemical sales include significant amounts of nonchemical products. f Fiscal year ends Sept. 30. g Chemical net profits. h Does not include all chemical products.

for more than a third of their total sales volume

Rank 1983	Rank 1982[a]		Chemical sales 1983 ($ millions)	Change from 1982	Chemical sales as % of total sales	Industry classification	Chemical operating profits[b] 1983 ($ millions)	Change from 1982	Chemical operating profits as % of total operating profits	Operating profit margin[c]	Chemical assets 1983 ($ millions)	Chemical assets as % of total assets	Operating return on chemical assets[d]
51	53	**Pennwalt**	$605	4.2%	62.0%	Basic chemicals	$ 43	−7.1%	58.1%	7.1%	$463	53.1%	9.3%
52	56	**Uniroyal**	593	15.0	29.1	Rubber products	65	54.9	40.6	11.0	465	31.3	14.0
53	48	**Kaiser Aluminum**	582	−9.3	20.4	Nonferrous metals	24	−43.9	def	4.2	488	13.9	5.0
54	50	**Esmark**[j]	580[e]	−7.8	14.1	Food	29	25.6	11.0	5.1	347	11.1	8.5
55	58	**Witco Chemical**	571	11.3	41.2	Specialty chemicals	54	40.2	36.2	9.5	276	37.7	19.6
56	54	**Standard Oil (Ohio)**	566	2.2	4.7	Petroleum	−3	def	def	def	642	3.9	def
57	55	**Koppers**	555[e]	3.7	35.4	Diversified	7	−14.8	8.4	1.3	316	26.9	2.3
58	45	**Farmland Industries**	542	−18.4	11.5	Agricultural supplies	−55	def	def	def	447	26.2	def
59	63	**National Starch**	508	8.8	67.1	Specialty chemicals	na	na	na	na	na	na	na
60	61	**NL Industries**	470	−1.4	33.8	Petroleum services	63	4.7	def	13.4	317	16.5	19.8
61	56	**Sun Co.**	467	−9.5	3.0	Petroleum	na	na	na	na	na	na	na
62	64	**International Flavors**	461	2.9	100.0	Specialty chemicals	111	9.3	100.0	24.0	432	94.2	25.6
63	62	**Cabot**[f]	460	−2.4	29.5	Specialty metals	44	−29.8	26.5	9.5	259	19.8	16.9
64	67	**Beatrice Foods**	453	8.1	20.3	Food	66	32.0	8.2	14.6	na	na	na
65	—	**Morton Thiokol**[i]	448	132.0	29.7	Diversified	47	168.2	27.3	10.5	533	46.3	8.9
66	65	**Freeport-McMoRan**	441	1.2	56.0	Agricultural chemicals	74	−21.0	52.0	16.8	235	16.6	31.6
67	60	**Kerr-McGee**	439	−10.1	12.5	Petroleum	−27	def	def	def	630	16.5	def
68	66	**Polysar**	436	1.5	100.0	Basic chemicals	na	na	na	na	na	na	na
69	72	**H. B. Fuller**[k]	426	28.2	100.0	Specialty chemicals	33	31.6	100.0	7.8	226	100.0	14.7
70	68	**Henkel**	400	1.5	100.0	Specialty chemicals	na	na	na	na	na	na	na
71	69	**Pfizer**	394	0.9	10.5	Drugs	5	def	0.7	1.3	394	10.0	1.3
72	70	**Liquid Air**	390	5.1	84.8	Basic chemicals	49	2.1	104.1	12.5	465	86.8	10.5
73	71	**InterNorth**	374	9.9	7.5	Natural gas	27	146.3	5.3	7.1	404	8.1	6.6
74	76	**GAF**	323	9.8	46.2	Specialty chemicals	65	16.4	211.1	20.0	198	47.8	32.6
75	84	**American Petrofina**	310	23.2	15.0	Petroleum	5	def	6.1	1.7	178	12.7	2.9
76	78	**Houston Natural Gas**[l]	305	9.9	10.3	Natural gas	34	7.0	10.8	11.0	387	14.2	8.7
77	74	**Tyler**	304	0.8	31.6	Diversified chemicals	22	51.7	31.7	7.2	158	31.6	13.9
78	85	**Soltex**	300	20.0	100.0	Basic chemicals	na	na	na	na	na	na	na
79	77	**Big Three Industries**	294	3.6	43.9	Petroleum services	71	−11.2	67.5	24.1	538	49.0	13.1
80	81	**Upjohn**	291	8.6	15.9	Drugs	−21	def	def	def	180	10.2	def
81	75	**Rhône-Poulenc**	290	−3.3	100.0	Specialty chemicals	na	na	na	na	na	na	na
82	87	**Engelhard**	273	10.2	24.9	Specialty metals	56	13.4	49.9	20.4	264	30.4	21.1
83	79	**Petrolite**[j]	267	−3.0	92.7	Specialty chemicals	33	−24.6	97.6	12.3	153	73.1	21.5
84	73	**Mississippi Chemical**[i]	263	−19.3	100.0	Farm cooperative	4	1333.3	100.0	1.6	343	100.0	1.3
85	83	**Emhart**	259	2.2	15.3	Machinery	24	2.6	15.6	9.2	113	11.1	21.1
86	82	**Vulcan Materials**	256	−2.7	31.2	Nonmetallic minerals	15	−67.3	16.4	5.7	na	na	na
87	91	**Boker Industries**	253	20.2	100.0	Agricultural chemicals	1	def	100.0	0.4	327	100.0	0.3
88	88	**Chemed**	252	9.4	92.8	Specialty chemicals	35	10.5	92.3	13.8	134	67.9	26.0
89	86	**SCM**[i]	251[e]	0.8	15.1	Paint	15	−32.6	16.5	6.0	267	24.0	5.7
90	80	**Terra Chemicals**	247	−9.5	100.0	Agricultural chemicals	na	na	na	na	173	100.0	na
91	93	**Aluminum Co. of America**	241	17.0	4.6	Nonferrous metals	na	na	na	na	na	na	na
92	94	**Ferro**	240[e]	16.9	38.8	Specialty materials	17	107.1	32.5	7.2	77	20.9	22.7
93	98	**Great Lakes Chemical**	226	33.2	100.0	Specialty chemicals	39	53.1	100.0	17.3	227	100.0	17.3
94	90	**Loctite**	216	−0.3	100.0	Specialty chemicals	29	17.3	100.0	13.5	213	100.0	13.7
95	89	**Martin Marietta**	214	−3.8	5.5	Aerospace	35	84.2	13.0	16.4	197	7.2	17.7
96	92	**Stepan Chemical**	207	−0.6	100.0	Specialty chemicals	11	20.7	100.0	5.4	145	100.0	7.7
97	—	**Essex Chemical**	169	11.2	100.0	Basic chemicals	17	−23.0	100.0	9.9	116	79.8	14.4
98	95	**Agway**	162	−16.0	4.3	Farm cooperative	na	na	na	na	na	na	na
99	—	**UGI Corp.**	149	−21.2	22.3	Natural gas	0	def	def	def	117	21.0	def
100	—	**Sterling Drug**	136	2.3	7.2	Diversified	7	56.5	2.8	5.3	112	7.6	6.4

[i] Fiscal year ends June 30. [j] Fiscal year ends Oct. 31. [k] Fiscal year ends Nov. 30. [l] Fiscal year ends July 31. na = not available. nm = not meaningful. def = deficit.

SHIPMENTS: Chemical industry sales grew more than those of industry as a whole in 1983

$ Billions	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	Annual change 1982–83	Annual change 1973–83
All manufacturing industries	$2052.8	$1910.1	$1994.6	$1851.0	$1727.2	$1523.4	$1358.4	$1185.6	$1039.1	$1017.5	$875.2	7%	9%
Chemicals and allied products	189.2	172.8	175.1	161.6	147.7	129.8	118.2	104.1	89.7	83.7	65.0	9	11
Industrial chemicals[a]	59.9	55.8	60.7	56.4	52.3	44.8	41.5	35.6	29.4	26.6	19.0	7	12
Drugs, soap, and toiletries	48.8	48.6	44.1	41.9	36.7	34.7	30.6	27.8	24.3	22.2	19.3	0	10
Petroleum and coal products	191.0	206.4	220.3	198.7	148.4	103.9	97.5	82.3	69.5	58.9	34.9	−7	19
Rubber and plastic products, nec	51.9	50.2	46.5	47.3	46.8	43.2	39.6	31.8	27.2	27.9	24.4	3	8
Paper and allied products	85.7	79.0	79.5	72.6	65.2	57.0	52.1	48.2	41.7	41.8	32.8	8	10

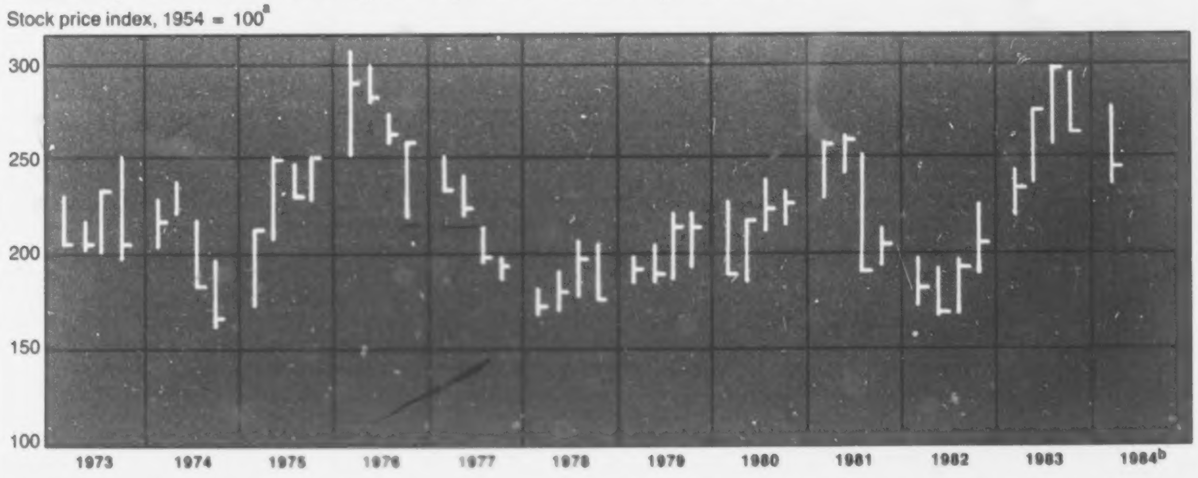
a Excluding pigments. **nec** = not elsewhere classified. **Source:** Department of Commerce

PRICES: Little or no increases in most chemical industry sectors

Producer price indexes,[a] 1967 = 100	Annual average 1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	Annual change 1982–83	Annual change 1973–83
All commodities	303.1	299.3	293.4	268.8	235.6	209.3	194.2	183.0	174.9	160.1	134.7	1%	8%
Industrial commodities	315.8	312.3	304.1	274.8	236.5	209.4	195.1	182.4	171.5	153.8	125.9	1	10
Chemicals and allied products	292.9	292.4	287.6	260.3	222.3	198.8	192.8	187.2	181.3	146.8	110.0	0	10
Industrial chemicals	342.9	353.0	363.3	324.0	264.0	225.6	223.9	219.3	206.9	151.7	103.4	−3	13
Prepared paint	264.7	262.9	249.8	235.3	204.4	192.3	182.4	174.4	166.9	145.7	122.2	1	8
Paint materials	305.6	304.6	300.1	273.9	241.2	212.7	205.9	189.8	177.2	152.3	113.2	0	10
Drugs and pharmaceuticals	226.2	210.1	193.5	174.5	159.4	148.1	140.5	134.0	126.6	112.7	104.3	8	8
Fats and oils, inedible	283.7	267.1	295.6	298.0	376.7	315.8	279.0	249.9	255.2	338.2	228.3	6	2
Agricultural chemicals and chemical products	280.7	292.7	285.0	257.1	214.4	198.4	187.8	188.4	203.6	137.7	96.6	−4	11
Plastic resins and materials	290.2	283.3	289.2	279.2	235.9	199.8	195.7	194.0	180.9	143.8	92.1	2	12
Other chemicals and allied products	273.4	269.8	254.2	224.5	191.8	181.8	175.7	170.7	168.6	147.5	118.1	1	9
Rubber and plastics products	243.4	241.6	232.6	217.4	194.3	174.8	167.6	159.2	150.2	136.2	112.4	1	8

a Formerly called "wholesale price indexes." **Source:** Department of Labor

Recovery in chemical stock prices peaked in third-quarter 1983



a C&EN weighted stock price index of Allied Corp., American Cyanamid, Celanese, Dow Chemical, Du Pont, Monsanto, and Union Carbide; weighted according to number of shares outstanding for each company. b First quarter.

INDUSTRY BALANCE SHEET: Liquidity is higher but assets and liabilities change little overall

Industrial chemicals and synthetics

Assets	1983 ($ billions)	1982 ($ billions)	Change
Current assets:			
Cash and time deposits in U.S.	$ 1.29	$ 1.04	23%
Marketable securities	1.68	1.36	24
Receivables	14.12	13.26	6
Inventories	11.70	12.43	−6
Other current assets	2.48	2.77	−10
Total	**31.27**	**30.86**	**1**
Fixed assets:			
Plant, property, and equipment	83.04	80.15	4
Less: accumulated depreciation and depletion	38.46	35.59	8
Net fixed assets	**44.58**	**44.56**	**0**
Other assets, including investments and intangibles	**17.50**	**17.54**	**0**
TOTAL ASSETS	**$93.34**	**$92.95**	**0%**

Note: Totals may not add because of rounding. **Source:** Bureau of the Census

Liabilities and stockholders' equity	1983 ($ billions)	1982 ($ billions)	Change
Current liabilities			
Accounts payable	$ 6.83	$ 6.28	9%
Short-term loans	1.76	1.78	−1
Accrued income taxes	1.25	0.50	151
Current portion of long-term debt	1.12	0.91	24
Other current liabilities	8.94	8.53	5
Total	**19.91**	**18.00**	**11**
Long-term debt	**19.54**	**22.04**	**−11**
Deferred taxes, minority interest, and other noncurrent liabilities	**8.17**	**6.97**	**17**
TOTAL LIABILITIES	**47.62**	**47.01**	**1**
Stockholders' equity			
Capital stock and other capital	17.84	17.85	0
Retained earnings	27.88	28.10	−1
TOTAL STOCKHOLDERS' EQUITY	**45.72**	**45.95**	**0**
TOTAL LIABILITIES AND STOCKHOLDERS' EQUITY	**$93.34**	**$92.95**	**0%**

DEBT RATIOS: Down moderately last year for the chemical industry

$ Billions	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
INDUSTRIAL CHEMICALS AND SYNTHETICS											
Long-term debt	$19.5	$22.0	$21.4	$16.8	$14.8	$13.6	$12.3	$11.8	$10.2	$ 7.8	$ 7.2
Stockholders' equity	$45.7	$45.9	$42.5	$39.8	$32.3	$29.3	$26.3	$25.0	$22.8	$20.5	$18.7
Debt ratio[a]	29.9%	32.4%	33.5%	29.6%	31.4%	31.8%	31.9%	32.0%	30.8%	27.6%	27.8%
CHEMICALS AND ALLIED PRODUCTS											
Long-term debt	$36.2	$38.2	$36.9	$28.3	$24.9	$23.5	$21.1	$19.4	$16.8	$12.8	$10.7
Stockholders' equity	$97.6	$95.3	$89.9	$79.5	$67.4	$60.8	$54.9	$50.8	$45.7	$40.9	$36.7
Debt ratio[a]	27.1%	28.6%	29.1%	26.3%	27.0%	27.9%	27.8%	27.6%	26.9%	23.8%	22.6%
ALL MANUFACTURING											
Long-term debt	$287.1	$293.1	$266.5	$236.2	$204.8	$182.0	$167.3	$153.6	$145.2	$130.1	$112.9
Stockholders' equity	$835.0	$783.0	$762.3	$699.7	$624.0	$560.8	$511.7	$475.3	$435.5	$408.4	$368.0
Debt ratio[a]	25.6%	27.2%	25.9%	25.2%	24.7%	24.5%	24.6%	24.4%	25.0%	24.2%	23.5%

a Long-term debt as a percentage of long-term debt plus stockholders' equity. **Note:** Because of changes in accounting rules and industry classifications, numbers over the entire range of years are not strictly comparable. **Source:** Bureau of the Census

CASH FLOW: Smaller shares of funds are provided by debt and consumed by capital outlays

$ Millions, % of total	1983		1982		1981		1980		1979	
SOURCES OF FUNDS										
Net income	$ 2,735	21.5%	$ 2,347	19.4%	$ 3,629	17.1%	$ 3354	33.9%	$3476	39.6%
Depreciation and depletion	4,633	36.4	4,346	36.0	3,633	17.1	3275	33.1	3129	35.6
Deferred taxes	362	2.8	570	4.7	906	4.3	603	6.1	422	4.8
Other internal sources	2,592	20.4	1,841	15.2	1,308	6.1	496	5.0	672	7.6
Long-term debt	1,899	14.9	2,554	21.1	7,190	33.9	1892	19.1	992	11.3
Stock	514	4.0	427	3.5	4,567	21.5	282	2.8	99	1.1
TOTAL	**$12,734**	**100.0%**	**$12,085**	**100.0%**	**$21,233**	**100.0%**	**$9902**	**100%**	**$8790**	**100.0%**
APPLICATIONS OF FUNDS										
Dividends	$ 1,754	13.8%	$ 1,682	13.9%	$ 1,569	7.4%	$ 1368	13.8%	$1287	14.6%
Capital expenditures	5,619	44.1	7,192	59.5	6,975	32.9	5867	59.3	4728	53.8
Additions to working capital	−343	−2.7	−1,548	−12.8	3,576	16.8	648	6.5	1033	11.8
Reduction of long-term debt	3,380	26.6	3,398	28.1	1,081	5.1	968	9.8	808	9.2
Other applications	2,324	18.2	1,361	11.3	8,032	37.8	1050	10.6	934	10.6
TOTAL	**$12,734**	**100.0%**	**$12,085**	**100.0**	**$21,233**	**100.0%**	**$9902**	**100.0%**	**$8790**	**100.0%**

Note: Data are totals for 12 major chemical companies: American Cyanamid, Celanese, Dow Chemical, Du Pont, Ethyl, Hercules, Monsanto, Olin, Pennwalt, Rohm & Haas, Union Carbide, and Williams Cos. **Source:** Company annual reports

FINANCIAL ANALYSIS: **In 1983, most analytical measures strengthened moderately**

		Profit margin[a]	Return on investment[b]	Debt as % debt plus equity	% total sales abroad[c]	% total assets abroad[d]	Sales per employee[e]	Dividends as % of net income	CAPITAL SPENDING[f] as % of sales	CAPITAL SPENDING[f] as % of net plant	R&D as % of sales	Sales as % of assets	Net plant as % of gross plant
SALES OVER $1 BILLION													
Air Products[g]	1983	6.7%	3.5%	28.3%	19.3%	17.8%	$ 98	25.4%	15.1%	16.0%	2.4%	73.6%	59.0%
	1982	6.7	3.5	36.1	28.5	18.6	83	21.9	22.1	23.2	2.4	71.1	61.5
American Cyanamid	1983	4.7	4.0	24.5	32.4	23.9	91	51.3	4.7	13.1	6.1	115.7	47.9
	1982	3.8	3.3	24.7	35.3	26.5	86	63.7	5.0	13.2	5.5	115.2	51.7
Celanese	1983	3.6	2.5	39.7	22.0	25.1	140	56.3	3.2	7.3	2.7	113.7	38.9
	1982	0.2	0.1	41.7	23.3	22.8	121	1340.0	9.0	17.1	3.3	107.0	43.0
Dow Chemical	1983	2.5	1.7	35.7	52.3	45.4	201	128.9	5.8	11.1	4.5	91.4	49.4
	1982	3.2	2.3	41.0	52.2	45.4	188	101.8	7.8	13.9	4.3	89.9	53.2
Ethyl	1983	6.6	6.8	25.6	15.5	11.1	134	31.7	4.9	13.5	2.3	115.6	51.9
	1982	5.7	5.5	30.9	16.4	11.1	115	36.6	5.7	13.8	2.4	106.0	55.0
W. R. Grace	1983	2.6	2.6	38.2	20.0	14.5	79	85.3	5.7	13.0	1.1	123.5	61.8
	1982	5.2	5.4	37.0	20.8	16.2	75	40.9	9.1	20.7	1.0	124.5	64.3
Hercules	1983	5.7	5.8	21.4	21.0	15.4	109	44.1	6.4	21.2	2.8	120.9	45.5
	1982	3.7	3.3	28.1	22.5	21.5	107	59.8	6.6	18.3	2.8	124.8	44.7
International Minerals[h]	1983	5.4	3.1	29.3	20.4	9.4	176	86.2	8.1	10.1	na	76.1	59.6
	1982	7.5	4.9	30.4	21.7	9.1	194	56.5	9.9	13.7	na	83.9	63.3
Monsanto	1983	6.2	4.1	20.4	27.0	18.2	124	43.8	8.9	17.1	4.6	98.0	49.5
	1982	5.4	3.8	22.3	29.1	19.9	124	46.5	10.6	20.3	4.2	104.1	50.7
Morton Thiokol	1983	5.2	6.7	21.3	15.3	16.4	90	30.1	4.7	13.6	1.5	131.1	72.8
	1982	6.2	5.5	15.3	20.2	15.3	112	42.5	4.8	18.3	1.0	105.4	56.3
National Distillers	1983	2.6	3.1	25.9	na	na	na	121.0	2.8	9.1	na	131.2	59.2
	1982	4.3	4.5	18.0	na	na	na	101.9	3.6	13.4	na	107.2	52.0
Olin	1983	3.7	2.6	31.3	7.3	9.9	106	40.9	6.3	14.4	2.6	105.8	44.1
	1982	2.9	2.1	26.7	6.1	10.2	104	53.1	7.6	16.5	2.6	111.4	47.2
PPG Industries	1983	6.3	4.7	21.1	22.1	22.6	100	36.9	12.2	20.5	3.5	101.9	59.6
	1982	4.7	3.5	21.5	22.3	20.6	89	52.4	13.7	22.6	3.9	100.8	59.5
Rohm & Haas	1983	7.5	6.4	20.1	35.4	24.6	165	27.4	3.8	13.8	5.4	124.1	38.6
	1982	4.1	3.7	22.9	37.1	27.3	158	48.1	6.9	23.0	5.0	133.9	42.1
Stauffer Chemical[i]	1983	def	def	24.8	20.3	10.9	138	def	7.7	9.2	4.7	65.4	57.8
	1982	8.2	4.7	28.3	16.9	9.8	148	46.5	10.9	14.7	3.8	73.9	60.6
Union Carbide	1983	2.8	1.8	32.6	31.2	30.3	90	96.3	8.5	12.1	2.7	87.4	58.7
	1982	3.4	2.2	32.0	33.2	30.1	88	75.8	13.0	18.5	2.6	85.4	58.9
Williams Cos.	1983	2.5	1.1	60.4	na	na	112	67.0	11.7	7.9	na	46.2	79.0
	1982	1.8	1.0	39.1	na	na	94	120.2	10.2	11.4	na	71.4	66.7
Witco Chemical	1983	3.8	5.4	30.4	14.6	13.7	na	34.8	3.2	14.3	na	189.1	53.4
	1982	2.3	3.5	33.1	14.2	13.8	na	57.0	4.1	18.5	na	197.3	54.7
MEDIAN 1983		**3.8%**	**3.8%**	**27.1%**	**20.7%**	**17.1%**	**$111**	**43.5%**	**7.6%**	**13.3%**	**2.8%**	**109.8%**	**55.6%**
MEDIAN 1982		**4.5%**	**3.5%**	**29.4%**	**22.9%**	**19.3%**	**$114**	**52.8%**	**8.4%**	**17.7%**	**3.1%**	**105.7%**	**55.7%**

a Net income as a percentage of sales. b Net income as a percentage of current assets plus gross plant. c Consolidated sales only. d Foreign identifiable assets as a percentage of total assets. e Thousands of dollars. f Actual spending on construction of new facilities and purchase of new equipment and land in consolidated businesses. g For fiscal year ended Sept. 30, 1983. h For fiscal year ended June 30, 1983. i Stauffer has changed its fiscal year to end Nov. 30. Figures for 1982 are for calendar year ended Dec. 31, so some double counting is involved.

		Profit margin[a]	Return on investment[b]	Debt as % debt plus equity	% total sales abroad[c]	% total assets abroad[d]	Sales per employee[e]	Dividends as % of net income	CAPITAL SPENDING[f]		R&D as % of sales	Sales as % of assets	Net plant as % of gross plant
									as % of sales	as % of net plant			
SALES LESS THAN $1 BILLION													
Beker Industries	1983	0.4%	0.3%	52.2%	na	na	$297	0.0%	3.8%	5.5%	na	77.3%	68.5%
	1982	def	def	53.4	na	na	na	def	8.8	10.3	na	69.1	72.0
Chemed	1983	6.4	12.1	44.6	13.4%	11.2%	na	62.6	2.1	16.3	0.9%	137.9	62.4
	1982	6.7	14.0	58.2	14.9	13.7	na	81.0	2.0	16.2	0.9	149.5	63.1
Crompton & Knowles	1983	2.7	4.6	24.6	19.3	21.2	na	61.9	1.3	19.5	1.9	182.6	56.6
	1982	2.4	3.8	24.4	21.6	23.0	na	75.0	1.7	10.8	2.0	165.1	61.2
Essex Chemical	1983	2.9	2.9	59.1	na	na	187	55.1	6.4	16.2	1.8	116.0	66.2
	1982	4.7	4.6	61.0	na	na	160	33.3	17.2	44.4	1.6	110.4	66.3
First Mississippi[h]	1983	6.9	3.4	35.3	na	na	251	34.8	23.2	23.6	na	53.8	64.4
	1982	10.4	5.8	24.5	na	na	na	21.4	30.4	36.9	na	56.5	67.9
Freeport-McMoRan	1983	11.5	4.6	27.2	na	na	164	47.3	29.6	21.3	na	55.4	62.6
	1982	11.1	3.9	39.6	na	na	150	50.4	64.2	36.4	na	45.1	68.4
H. B. Fuller[j]	1983	3.2	5.6	36.0	39.0	50.9	104	18.1	3.5	18.3	2.0	188.4	67.0
	1982	2.6	3.8	35.1	32.6	52.6	83	27.9	5.1	22.9	2.1	160.1	68.5
Great Lakes	1983	10.5	8.5	15.1	19.9	na	na	0.7	10.4	19.3	3.4	99.5	63.9
	1982	9.7	6.7	21.9	16.5	na	na	0.9	20.5	30.6	3.5	84.0	66.7
International Flavors	1983	14.8	12.7	0.0	65.6	48.5	125	56.1	5.8	19.2	6.9	100.6	59.3
	1982	14.1	12.4	0.0	67.0	51.7	124	59.0	6.3	20.9	6.8	103.8	58.8
Lawter International	1983	15.9	16.1	8.1	31.3	37.6	na	59.4	3.7	15.6	1.8	119.0	59.4
	1982	12.5	13.2	1.8	34.6	39.4	na	82.0	5.4	20.9	1.8	125.0	61.7
Liquid Air	1983	5.2	3.4	31.5	34.7	35.9	113	89.5	9.1	11.7	1.8	85.8	60.5
	1982	6.1	4.0	33.0	38.3	37.4	na	76.4	13.1	16.6	1.5	83.6	64.0
Loctite[h]	1983	7.9	8.2	10.8	40.5	45.0	92	32.7	4.6	21.3	2.8	101.3	66.4
	1982	7.3	7.7	11.5	42.6	45.3	87	34.8	5.0	24.5	2.6	108.3	68.5
Lubrizol	1983	8.1	7.5	5.5	52.3	36.5	192	65.4	3.1	9.1	4.6	117.2	54.7
	1982	5.9	6.0	4.0	50.3	38.5	188	88.9	6.4	17.9	4.4	126.2	58.8
Nalco Chemical	1983	10.8	11.5	5.0	21.0	21.0	143	63.9	6.1	21.1	4.5	134.8	49.3
	1982	10.0	11.1	4.8	21.3	24.1	140	68.9	8.7	28.9	5.2	138.5	52.7
Pennwalt	1983	4.6	3.9	26.9	18.6	12.4	100	61.2	7.1	20.0	3.4	111.9	51.2
	1982	2.6	2.4	31.3	19.1	15.6	100	95.1	8.0	22.3	3.2	125.9	52.0
Petrolite[k]	1983	7.7	7.7	5.5	19.5	15.1	na	53.8	3.2	12.3	4.0	137.7	48.2
	1982	9.7	11.0	6.6	20.9	18.2	na	38.6	7.8	29.5	3.1	151.1	53.3
Reichhold Chemicals	1983	2.7	4.2	21.6	11.1	11.4	na	31.3	2.6	11.0	2.2	194.2	59.3
	1982	0.9	1.5	25.8	16.8	13.1	na	91.3	2.6	12.9	2.2	214.4	58.1
Stepan Chemical	1983	3.0	3.3	27.1	na	na	235	33.3	4.7	12.9	3.4	142.8	55.9
	1982	2.5	2.8	31.4	na	na	227	67.7	7.7	21.3	3.2	127.9	59.4
MEDIAN 1983		**6.7%**	**5.2%**	**25.8%**	**21.0%**	**36.2%**	**$154**	**54.5%**	**4.7%**	**16.3%**	**2.8%**	**116.6%**	**60.0%**
MEDIAN 1982		**6.4%**	**5.2%**	**25.2%**	**21.6%**	**30.8%**	**$140**	**61.2%**	**7.8%**	**21.8%**	**2.6%**	**125.5%**	**62.4%**

j For fiscal year ended Nov. 30, 1983. **k** For fiscal year ended Oct. 31, 1983. **Note:** Net income is from continuing operations, excluding extraordinary and nonrecurring items where possible. **na** = not available. **def** = deficit

INDUSTRY CAPITAL SPENDING: Increase budgeted for chemicals and allied products

$ Billions	1984[a]	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Chemicals	$ 14.34	$ 13.28	$ 13.27	$ 13.60	$ 12.60	$10.78	$ 8.46	$ 8.14	$ 8.12	$ 7.63	$ 6.48
Iron and steel	3.27	2.97	3.47	3.17	3.29	3.09	2.52	2.79	3.04	3.03	1.94
Nonferrous metals	2.73	2.44	2.71	3.46	3.11	2.39	2.11	1.88	1.97	2.18	2.04
Paper	7.13	6.18	5.97	6.72	6.80	5.55	3.99	3.59	3.11	2.98	2.90
Petroleum	26.51	23.48	26.69	26.56	20.69	16.21	13.95	12.70	10.76	9.59	7.31
Rubber	2.21	1.91	1.71	1.77	1.73	2.17	2.10	1.66	1.32	1.15	1.56
Stone, clay, glass	2.81	2.45	2.61	3.14	3.82	3.94	3.10	2.23	1.88	1.67	1.64
All manufacturing	129.72	111.53	119.68	126.79	115.81	98.68	79.72	69.22	59.95	54.92	53.21

[a] Estimate. **Source:** Department of Commerce

Backlog of unspent capital funds changed little for chemical industry in 1983

$ Billions	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
Chemicals	$ 7.5	$ 7.4	$ 9.4	$ 9.8	$ 8.5	$ 7.2	$ 7.4	$ 7.1	$ 6.9	$ 6.6	$ 4.9
Iron and steel	2.2	2.7	5.4	3.9	4.5	4.0	3.6	4.7	5.4	5.8	2.4
Nonferrous metals	3.2	3.2	3.7	3.7	2.9	2.7	2.9	2.4	2.2	2.7	2.2
Paper	4.0	5.1	5.1	4.0	4.2	3.2	2.6	2.0	2.7	2.9	1.7
Petroleum, coal	22.3	22.9	29.7	26.7	16.1	14.6	15.0	12.2	14.1	12.8	7.1
Rubber	1.1	1.0	0.9	1.0	0.9	0.9	0.8	0.7	0.6	0.7	0.9
Stone, clay, glass	1.5	1.6	1.9	2.0	2.3	2.4	2.0	1.5	1.4	1.7	1.5
All manufacturing	73.7	70.8	92.7	91.9	76.7	63.4	56.5	47.5	46.4	49.8	37.1

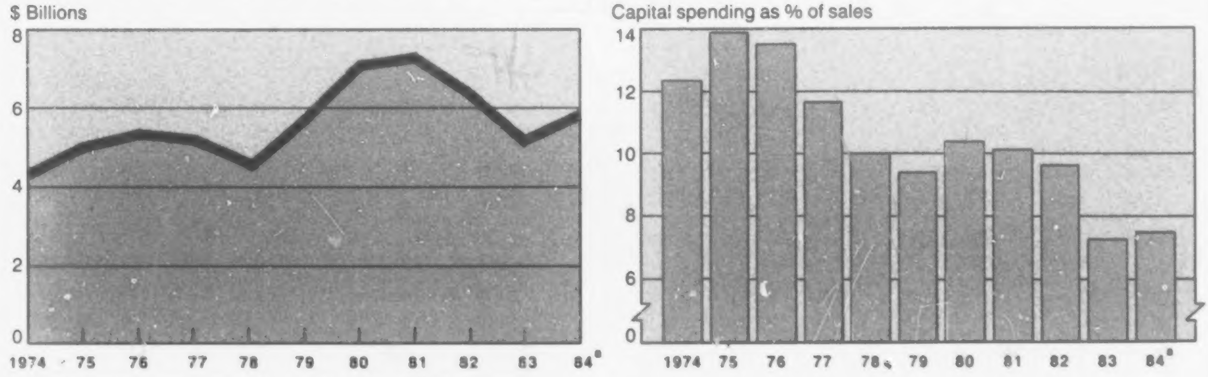
Note: Figures are for fourth quarter of each year. **Source:** Conference Board

U.S. chemical firms plan small rise in overseas investment

$ Billions[a]	1984[b]	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Chemicals and allied products	$ 2.9	$ 2.5	$ 2.8	$ 3.0	$ 3.0	$ 2.6	$ 1.9	$ 2.0	$ 2.7	$ 2.5	$ 2.1
Metals, primary and fabricated	1.1	0.8	0.9	0.8	0.9	0.6	0.6	0.5	0.7	0.7	0.7
Petroleum	19.4	17.5	19.7	15.8	14.8	11.0	9.5	8.9	7.9	8.9	7.8
All manufacturing	16.0	13.8	16.8	19.2	19.5	15.4	12.0	10.5	10.9	11.3	11.6

[a] By majority-owned foreign affiliates of U.S. companies; data after 1976 are not consistent with earlier years. [b] Planned. **Source:** Department of Commerce

Chemical capital spending, although up a bit this year, remains low relative to sales



$ Billions

Capital spending as % of sales

[a] Planned. **Source:** Worldwide data for 14 major U.S. basic chemical companies

Capital spending in the chemical industry is once again on the increase. But that increase is tempered somewhat by the realities of the marketplace.

Capacity utilization rates are still relatively low compared with historic rates and so do not justify increased spending on new plant and equipment. And a prime lending rate of around 13% is causing companies to look twice in comparing the cost of capital to the expected rate of return for new capacity.

Thus, this year, much of the capital spending that is taking place is for upgrading and modernizing existing plants. Chemical makers are improving operating efficiencies and, in many cases, they are increasing capacity by doing so.

Then, too, this type of capital spending, which is less expensive than building new plants, allows companies to obtain their capital funds from their own internal cash flow. This is helping to keep them away from credit markets.

The high cost of money also is discouraging a massive buildup in plant, as happened in previous recoveries to eventually dampen capacity utilization throughout the late 1970s.

An update of C&EN's annual survey of worldwide capital spending by 14 major chemical companies shows that spending on plant and equipment will rise about 15% in 1984 to almost $5.9 billion from 1983. Although this seems like a large increase, it follows a 21% decline in 1983. Thus, 1984 planned spending is still 10% below 1982 levels of almost $6.5 billion. This means capital spending will be about 7.5% of sales in 1984, compared to 7.3% in 1983 but 9.6% in 1982.

C&EN's survey of the 14 companies shows an average spending increase that is much higher than that shown by the Commerce Department in its survey of planned capital spending. In the government's latest survey, capital spending in the much broader chemicals and allied products category is forecast to rise 8% to $14.3 billion from 1983. The Commerce Department, though, shows practically no change between 1982 and 1983, compared to the decline shown by C&EN's figures.

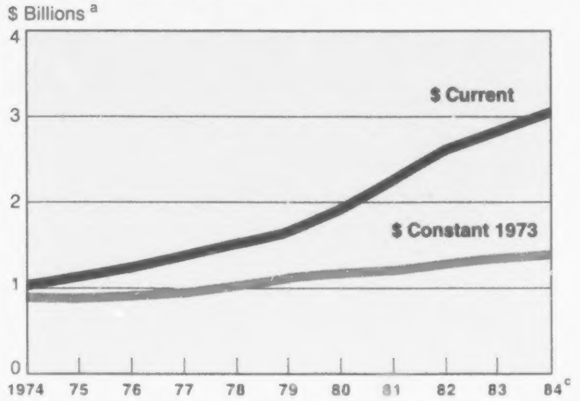
The Commerce Department also is forecasting a resurgence of overseas spending by majority-owned foreign affiliates of U.S. companies, following a two-year decline. Overseas spending for chemicals and allied products, according to the latest government figures, will rise 15% in 1984 to $2.9 billion. The 1983 figure was off 11% from $2.8 billion in 1982.

CHEMICAL CAPITAL SPENDING: Most companies increase budgets after two years of cuts

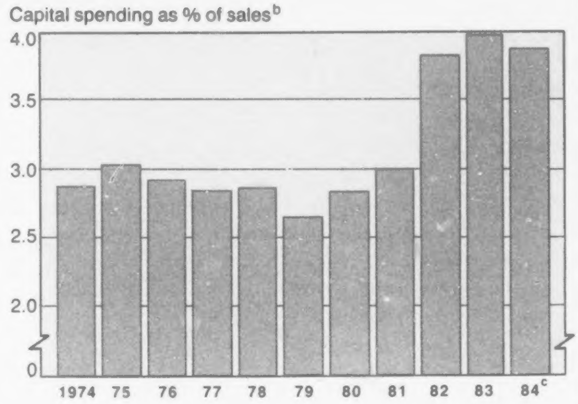
$ Millions	1984[a]	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Air Products	$ 300	$ 246	$ 347	$ 323	$ 364	$ 246	$ 200	$ 143	$ 162	$ 151	$ 110
American Cyanamid	190	165	171	181	196	235	251	235	232	204	139
Celanese	175	105	275	414	253	245	248	243	223	208	220
Dow Chemical	750	630	829	1176	1184	1268	1075	1163	1200	935	890
Du Pont[b]	1500	1276	1300	1420	1297	864	714	704	876	1036	1008
Ethyl	95	85	92	141	156	123	96	88	88	69	75
Grace	450	353	560	657	658	514	313	279	234	309	303
Hercules	200	168	174	167	229	186	116	127	150	151	217
Monsanto	600	560	673	668	781	566	480	607	647	528	313
Olin	175	123	139	186	172	161	163	208	166	99	67
PPG Industries	400	450	452	376	401	252	261	212	177	176	205
Rohm & Haas	130	72	126	182	93	68	66	79	110	106	106
Stauffer Chemical	130	104	177	239	246	239	201	193	199	199	83
Union Carbide	775	761	1179	1186	1129	831	688	805	965	862	517
TOTAL	**$5870**	**$5097**	**$6493**	**$7316**	**$7159**	**$5798**	**$4872**	**$5086**	**$5429**	**$5033**	**$4253**
ANNUAL CHANGE	**15%**	**−21%**	**−11%**	**2%**	**23%**	**19%**	**−4%**	**−6%**	**8%**	**18%**	**58%**

a Planned. b Excludes Conoco. **Note:** Figures are for worldwide spending on construction, equipment, and land in consolidated businesses. Where possible, acquisition costs and investments in nonconsolidated businesses are excluded. **Source:** Company data

This year will bring another solid increase in chemical companies' R&D budgets . . .



. . . keeping outlays high relative to company sales volume



a R&D spending by basic chemical companies **b** By basic chemical companies. **c** Estimates.
Sources: Worldwide data for 15 U.S. basic chemical companies, Battelle Columbus Laboratories, C&EN estimates

For the second year in a row, R&D spending by the U.S. chemical industry is rising only 8%, according to C&EN's survey of 15 chemical companies. That contrasts sharply with the double-digit budget increases that characterized the 1978–82 period, when spending jumped at a rate of nearly 15% per year.

Still, chemical industry spending on R&D has risen uninterruptedly over the past decade at an annual rate of 11%. Adjusted for the heady inflation of the past 10 years, on the other hand, the annual increase has been slightly under 4%. This year, factoring in expected inflation of industrial research costs, spending will climb just 3% above 1982's $2.8 billion, but that is a bit better than the 2% increase in outlays for R&D that 1982 registered over the year before.

At the same time, however, chemical industry spending continues to reflect a heightened emphasis on R&D. Research budgets may have been growing faster during the 1970s, but so were company revenues; R&D spending averaged just 2.9% of sales between 1974 and 1981. In 1982, that percentage jumped to 3.8%, thanks both to a 14% budget hike overall and a sharp cut in industry sales. The higher plateau has been maintained, however, and in 1984, the second year of recovery, R&D spending is forecast by C&EN to amount to nearly 4% of sales down only slightly from 1983's 4.0%.

CHEMICAL R&D SPENDING: Increases are more moderate than those of early 1980s

$ Millions	1984[a]	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Air Products	$ 42	$ 40	$ 37	$ 32	$ 30	$ 24	$ 23	$ 24	$ 19	$ 16	$ 11
American Cyanamid	235	215	190	172	148	130	108	96	83	73	64
Celanese	100	88	102	104	94	92	83	77	70	64	58
Dow Chemical	508	492	460	404	314	269	232	203	188	167	149
Du Pont	945	875	775	647	591	509	461	367	353	336	344
Ethyl	39	39	39	37	34	29	25	28	25	19	25
W. R. Grace	82	71	62	55	45	42	37	32	28	30	32
Hercules	66	74	74	65	57	50	43	40	37	32	32
Lubrizol	38	37	36	33	28	23	21	19	17	17	15
Monsanto	385	290	264	233	208	161	136	132	114	116	87
Olin	55	51	47	39	31	26	25	25	23	24	19
PPG Industries	125	127	127	119	103	83	70	61	56	50	47
Rohm & Haas	100	100	92	77	67	54	49	45	43	45	39
Stauffer Chemical	66	63	57	49	44	35	32	32	28	23	20
Union Carbide	250	245	240	207	166	161	156	156	143	120	94
TOTAL	**$3036**	**$2807**	**$2602**	**$2273**	**$1960**	**$1688**	**$1501**	**$1337**	**$1227**	**$1132**	**$1036**
ANNUAL CHANGE	**8%**	**8%**	**14%**	**16%**	**16%**	**12%**	**12%**	**9%**	**8%**	**9%**	**21%**

a Planned. **Source:** Company data

Finances of the U.S. Chemical Industry 2

The annual reports issued by U.S. chemical companies earlier this year, covering the results of their operations during 1983, certainly brought much more cheerful reading than those published a year earlier. A rapidly recovering U.S. economy bolstered demand for most chemical products—although agricultural chemicals were a notable exception—and, as a result of the recession-bred cost-cutting efforts of the past two or three years, a bigger share of each sales dollar could be carried through to profits.

Meanwhile, chemical companies were being tightfisted with regard to spending for new plant and equipment, the biggest single outlet for their corporate funds. Demand for chemicals, even in a recovery year, was still far from enough to force producers to operate their manufacturing facilities full tilt and so encourage a burst of capital expenditures. As a result, the cash generated by higher profits was being put to other uses, such as increasing dividend payments or adding to working capital.

All this is evident from the data for 33 individual chemical companies and 16 pharmaceutical companies that are presented on this and the following four pages. Not all the companies covered participated in the overall recovery, of course. But even for some for whom last year's results look poorer than those of the previous year, the unfavorable comparison is more the result of corporate restructuring and the disposal of unwanted operations than a decline in the firm's continuing lines of business.

Explanation of table headings

Year. Data are for calendar year unless otherwise indicated.

Net sales. Gross sales, less discounts, allowances, and returns; generally excludes excise taxes and other operating income or revenues.

Net income. Net sales and other income, less operating costs, nonoperating charges, depreciation, depletion, interest expense, deferred charges, minority interest in income, and taxes. Nonrecurring or extraordinary credits and charges have been excluded in most cases, but these items are indicated by a footnote.

Total assets. Sum at year's end of current assets, investments, prepaid expenses, net plant and equipment, and other tangible assets. Excludes insofar as possible intangible assets including goodwill, value of patents and trademarks, and the like.

Current ratio. The ratio of current assets (cash, marketable securities, receivables, and inventories but excluding prepaid expenses) to total current liabilities.

Net plant and equipment. Value at year's end of fixed assets, less accumulated depreciation, amortization, and depletion.

Capital expenditures. Total spending during the year for new fixed assets, such as plant, equipment, and land, and for replacement and modernization of facilities.

Net worth. Equity at year's end of preferred and common stock holders, including value of capital stock, capital and earned surplus, and surplus reserves, as well as contingency and miscellaneous reserves for which no definite purpose is stated. Intangible assets are deducted insofar as possible.

Net income (breakdown). **Per cent of sales:** net income divided by net sales. **Per cent of net worth:** net income divided by tangible net worth. **Dollars per share:** net income, less preferred dividends, divided by the number of shares of common stock outstanding. All figures are adjusted for stock splits, but no adjustment has been made for earlier years as a result of stock dividends or for dilution that might result from the conversion of preferred stock or debt to common stock or the exercise of stock options outstanding.

Dividends per share. Cash dividends paid (or declared) on each share of common stock, excludes the value of stock dividends, which are indicated by a footnote.

Dividend yield. Dividends per share divided by the average of the high and low prices of the common stock during the calendar year.

Stock price range. High-low market prices of common stock during the calendar year, adjusted for stock splits but not for stock dividends.

Price-earnings ratio. Average of the high and low prices of the common stock during the calendar year divided by net income per share of common stock.

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME % of sales	NET INCOME % of net worth	NET INCOME $ per share	Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price earnings ratio
					Money figures in thousands of dollars unless otherwise indicated									
CHEMICALS														
Air Products & Chemicals														
1983[a]	$1.634.246	$108.963	$2.160.157	1.1	$1.541.345	$246.417	$988.256	6.7%	11.0%	$3.55	$0.90	2.1%	$ 51–34	12.0
1982[a]	1.568.916	105.654[b]	2.118.882	1.2	1.497.162	346.680	867.565	6.7	12.2	3.68[b]	0.80	2.5	41⅛–23⅝	8.8
1981[a]	1.570.115	126.039	1.871.986	1.2	1.301.922	323.465	769.134	8.0	16.4	4.42	0.80	1.9	48⅞–34	9.4
1980[a]	1.420.759	115.502	1.744.392	1.3	1.182.567	364.013	658.596	8.1	17.5	4.07	0.80	1.8	54¼–32¼	10.6
American Cyanamid Co.														
1983	$3.535.514	$166.356	$3.031.311	2.1	$1.255.658	$165.068	$1.378.875	4.7%	10.5%	$3.41	$1.75	3.8%	$ 59–33⅝	13.6
1982	3.453.674	132.127	2.985.004	2.0	1.296.204	171.047	1.526.390	3.8	8.7	2.74	1.75	5.7	37½–24⅜	11.3
1981	3.649.073	197.054	3.049.917	1.9	1.325.063	180.597	1.513.457	5.4	13.0	4.11	1.675	5.5	36½–24½	7.4
1980	3.453.934	159.195	2.900.289	1.8	1.328.691	195.819	1.419.073	4.6	11.2	3.32	1.60	5.5	38–20⅝	8.8
Beker Industries Corp.														
1983	$252.730	$ 1.001[c]	$326.818	1.1	$176.725	$ 9.687	$112.460	0.4%	0.9%	$0.08[c]	0.00	0.0	$12¼–5½	110.9
1982	210.185	(5.256)[d]	304.073	0.8	178.796	18.534	102.015	—	—	(0.44)[d]	0.00	0.0	8⅝–3⅞	—
1981	206.813	1.254[e]	342.935	1.0	189.135	65.486	115.289	0.6	1.1	0.11[e]	0.00	0.0	25–7½	147.7
1980	248.079	25.691[f]	286.821	1.3	133.850	32.150	119.748	10.4	21.5	2.21[f]	0.00	0.0	25–8⅞	7.7
Betz Laboratories														
1983	$266.983	$33.100	$204.174	2.1	$110.872	$32.795	$161.766	12.4%	20.5%	$2.08	$0.94	2.4%	$44¾–32¼	18.5
1982	254.717	30.561	186.320	2.0	97.382	24.769	143.421	12.0	21.3	1.93	0.82	2.4	42¼–24¾	17.4
1981	252.545	28.815	165.650	2.7	71.914	16.526	126.799	11.4	22.7	1.83	0.68	2.5	33¼–21¾	15.0
1980	212.607	23.379	139.018	3.1	61.955	13.898	109.134	11.0	21.4	1.50	0.56	2.7	25⅝–15⅞	13.8

a Fiscal year ends Sept. 30. b Excludes extraordinary gain for debt-for-equity exchange of $2.8 million ($0.10 per share) and credit for cumulative effect of change in accounting principle for investment tax credit of $61.9 million ($2.16 per share). c Excludes extraordinary net gain on termination of pension plan of $1.8 million ($0.16 per share). d Net loss; excludes net loss from discontinued operations and their disposition of $8.0 million ($0.68 per share). e Excludes net loss from discontinued operations of $6.1 million ($0.52 per share). f Excludes net earnings from discontinued operations of $3.2 million ($0.28 per share).

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
Big Three Industries														
1983	$668,841	$ 45,331	$1,097,602	3.0	$763,863	$ 71,581	$615,720	6.8%	7.4%	$1.07	$0.74	3.2%	$27¾–18½	21.6
1982	767,785	86,812	1,055,313	3.0	773,777	162,293	609,792	11.3	14.2	2.05	0.72	3.3	28½–15⅛	10.6
1981	823,280	108,854	1,015,259	2.7	680,709	158,234	555,765	13.2	19.6	2.57	0.60	1.9	37⅝–25	12.2
1980	659,121	86,604	815,048	2.2	583,772	142,542	472,607	13.1	18.3	2.05	0.47[a]	1.7	36⅛–18⅞	13.4
Cabot Corp.														
1983[b]	$1,558,016	$ 64,162	$1,293,340	2.6	$656,894	$ 76,964	$658,838	4.1%	9.7%	$2.00	$0.92	3.6%	$30⅞–20½	12.8
1982[b]	1,587,658	88,007	1,300,553	2.2	664,434	138,342	624,069	5.5	14.1	2.77	0.92	4.4	25½–16⅛	7.5
1981[b]	1,622,755	110,167	1,238,729	2.2	595,234	192,348	586,226	6.8	18.8	3.50	0.86	2.9	35½–23⅞	8.5
1980[b]	1,403,743	94,024[c]	1,138,683	2.0	456,507	117,705	497,546	6.7	18.9	3.00[c]	0.67	2.6	36⅜–14¾	8.5
Celanese Corp.														
1983	$3,261,000	$112,000	$2,869,000	1.7	$1,445,000	$105,000	$1,169,000	3.4%	9.6%	$6.89	$4.00	6.4%	$79¾–45	9.1
1982	3,062,000	(34,000)[d]	2,862,000	1.9	1,608,000	275,000	1,131,000	. . .	. . .	(2.45)[d]	4.00	7.9	59⅞–41¼	. . .
1981	3,752,000	144,000	2,991,000	2.0	1,518,000	414,000	1,233,000	3.8	11.7	9.01	3.85	6.4	69¼–51⅝	6.7
1980	3,348,000	122,000	2,633,000	2.0	1,197,000	253,000	1,101,000	3.6	11.1	8.20	3.50	6.8	62⅝–39⅞	6.2
Chemed Corp.														
1983	$271,343	$17,371[e]	$174,248	1.9	$35,012	$5,703	$ 58,420	6.4%	29.7%	$2.17[e]	$1.36	3.8%	$39⅜–32	16.4
1982	249,019	16,824[f]	152,735	1.7	30,887	5,008	36,448	6.8	46.2	1.79[f]	1.25	4.7	36–17⅜	14.9
1981	250,638	25,166[g]	216,915	2.7	29,583	5,481	168,542	10.0	14.9	1.26[g]	1.14	5.2	25–19	17.5
1980	219,019	18,973[h]	193,494	2.8	27,482	4,729	153,724	8.7	12.3	0.97[h]	1.04	6.0	19¾–14⅞	17.8
Crompton & Knowles Corp.														
1983	$230,560	$6,302	$125,388	2.7	$31,205	$2,954	$57,893	2.7%	10.9%	$1.81	$1.06	4.6%	$28⅞–16¾	12.6
1982	213,250	5,199	117,902	2.6	33,055	3,582	59,320	2.4	8.8	1.44	1.04	6.6	19⅝–12⅛	9.1
1981	243,412	8,571	132,197	2.3	32,668	6,699	63,606	3.5	13.5	2.51	0.95	6.1	18⅛–12⅞	6.2
1980	241,776	7,666	135,619	2.5	34,731	9,623	58,935	3.2	13.0	2.22	0.80	5.8	16⅝–10⅞	6.2
Dow Chemical Co.														
1983	$10,951,000	$293,000[i]	$11,785,000	1.4	$5,695,000	$ 630,000	$4,851,000	2.7%	6.0%	$1.50[i]	$1.80	5.7%	$38⅜–25	21.1
1982	10,618,000	342,000[j]	11,612,000	1.8	5,961,000	829,000	4,845,000	3.2	7.1	1.77[j]	1.80	7.4	28⅞–19⅝	13.7
1981	11,873,000	564,000	12,268,000	1.7	6,174,000	1,176,000	4,663,000	4.8	12.1	3.00	1.80	5.8	39–23⅜	10.4
1980	10,626,000	753,000[k]	11,429,000	1.5	5,672,000	1,184,000	4,331,000	7.1	17.4	4.14[k]	1.60	4.7	39¼–28¼	8.2
E. I. du Pont de Nemours & Co.														
1983	$35,378,000	$1,127,000	$24,432,000	1.7	$14,261,000	$2,628,000	$11,472,000	3.2%	9.8%	$4.70	$2.50	5.5%	$ 55–35½	9.6
1982	33,331,000	894,000	24,343,000	1.7	14,004,000	3,295,000	10,850,000	2.7	8.2	3.75	2.40	6.5	44⅜–30	9.9
1981	22,810,000	1,081,000[l]	23,829,000	2.0	12,722,000	2,389,000	10,458,000	4.7	10.3	5.81[l]	2.75	6.0	56–35¾	7.9
1980	13,652,000	716,000	9,560,000	2.3	4,414,000	1,279,000	5,690,000	5.2	12.6	4.83	2.75	6.8	49½–31⅛	8.3
Ethyl Corp.														
1983	$1,745,193	$106,038	$1,449,982	2.0	$626,461	$ 84,723	$811,260	6.1%	13.1%	$2.61	$0.85	3.9%	$29⅜–14½	8.4
1982	1,614,626	94,166	1,458,534	2.2	666,186	91,915	766,175	5.8	12.3	2.34	0.75	5.7	17⅛–9	5.6
1981	1,757,[illegible]95	90,891	1,194,630	2.2	658,282	140,520	683,001	5.2	13.3	2.28	0.75	5.3	17¼–10⅞	6.2
1980	1,740,627	82,397[m]	1,138,233	2.4	602,029	156,388	631,831	4.7	13.0	2.05[m]	0.75	5.1	18¼–11⅛	7.1
Ferro Corp.														
1983	$619,179	$19,228	$364,861	1.9	$132,509	$20,252	$185,337	3.1%	10.4%	$3.04	$1.20	3.7%	$39⅞–24⅝	10.6
1982	595,830	10,277[n]	345,922	2.0	133,318	22,650	161,945	1.7	6.3	1.37[n]	1.20	4.9	30½–18½	17.9
1981	702,213	25,503	389,405	2.1	135,587	24,243	222,441	3.6	11.5	3.30	1.20	4.6	31½–20¾	7.9
1980	695,580	29,019	430,472	2.0	134,563	31,505	220,597	4.2	13.2	3.77	1.20	5.8	24¼–17	5.5
First Mississippi Corp.														
1983[o]	$203,976	$14,146	$379,436	1.3	$200,990	$47,428	$155,055	6.9%	9.1%	$0.69	$0.24	2.0%	$15½–8¼	17.2
1982[o]	222,977	23,212[p]	394,587	1.0	183,994	67,882	145,407	10.4	16.0	1.11[p]	0.24	2.2	16–6	9.9
1981[o]	357,697	29,704	318,926	1.5	117,244	58,277	138,384	8.3	21.5	1.38	0.23	1.2	26⅛–13⅛	14.2
1980[o]	242,690	21,154	236,579	2.1	83,525	37,202	113,672	8.7	18.6	0.98	0.18	0.9	30¾–7½	19.5
W. R. Grace & Co.														
1983	$6,219,500	$159,700[q]	$4,946,600	1.6	$2,715,400	$353,100	$2,094,300	2.6%	7.6%	$3.28[q]	$2.80	6.3%	$50⅜–38⅜	13.5
1982	6,127,600	319,500[r]	4,854,300	1.7	2,706,400	559,500	2,136,600	5.2	15.0	6.62[r]	2.70	7.2	46¼–28½	5.6
1981	6,520,800	361,300[s]	4,947,100	1.5	2,528,600	656,900	1,986,600	5.5	18.2	7.50[s]	2.45	5.0	59⅝–38½	5.5
1980	6,101,300	283,800[t]	4,281,500	1.5	2,162,700	657,400	1,713,100	4.7	16.6	6.08[t]	2.175	4.5	63½–32⅝	7.9
Great Lakes Chemical Corp.														
1983	$225,950	$23,842	$217,916	2.1	$121,411	$23,393	$132,286	10.6%	18.0%	$1.63	$0.30	1.1%	$39¾–16¾	17.3
1982	169,703	13,945[u]	192,127	2.2	113,659	19,143	111,782	8.2	12.5	0.96[u]	0.26	1.6	20⅛–12½	16.9
1981	150,333	18,031	170,198	1.9	98,580	22,777	108,878	12.0	16.6	1.25	0.22	0.9	29¼–18⅛	18.9
1980	126,705	18,948	118,407	3.2	61,747	20,496	93,258	15.0	20.3	1.33	0.18	0.8	25⅝–17⅞	16.3

[a] Plus 5% stock dividend. [b] Fiscal year ends Sept. 30. [c] From continuing operations; excludes net income from discontinued operations of $12.3 million ($0.39 per share) and net gain on sale of machinery division of $46.4 million ($1.49 per share). [d] Net loss; includes special charge related to 40% equity in Mexican affiliate of $39 million ($2.50 per share). [e] Excludes net gain on disposition of discontinued Dearborn Group operations of $875,000 ($0.11 per share). [f] Excludes net income from discontinued Dearborn Group operations of $1.9 million ($0.11 per share). [g] Excludes net income from discontinued Dearborn Group operations of $11.2 million ($0.56 per share). [h] Excludes net income from discontinued Dearborn Group operations of $9.7 million ($0.50 per share). [i] Includes pretax gain on sales of investments of $101 million but excludes extraordinary net gain on debt-for-equity exchange of $41 million ($0.21 per share). [j] Includes pretax gain on sales of investments of $214 million but excludes extraordinary net gain on debt-for-equity exchange of $57 million ($0.30 per share). [k] Excludes net gain on sale of Wanda Petroleum Co. of $52 million ($0.28 per share). [l] Excludes cumulative effects of change in accounting for investment tax credits of $320 million ($1.74 per share). [m] Excludes net gain on sale of property of $7.3 million ($0.19 per share). [n] Includes loss on divestitures of $1.9 million ($0.23 per share). [o] Fiscal year ends June 30. [p] From continuing operations; excludes net loss from discontinued FirstMiss subsidiary of $6.4 million ($0.30 per share). [q] Includes net gains on disposal of businesses of $5.7 million. [r] Includes gain on restructuring Chemed Corp. of $65.1 million and net losses on disposal of businesses of $600,000. [s] Includes net gains on disposal of businesses of $31.1 million. [t] Includes net gains on disposal of businesses of $10.3 million. [u] Excludes net gain on sale of real estate of $2.5 million ($0.34 per share).

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
Hercules														
1983	$2,628.954	$174.222	$2,175.173	2.1	$793.313	$167.993	$1,288.118	6.6%	13.5%	$3.17	$1.38	3.9%	$43⅛–27¼	11.1
1982	2,468.971	86.861[a]	2,001.354	2.2	923.676	164.997	1,078.911	3.5	8.1	1.97[a]	1.32	5.8	28¾–16⅞	11.6
1981	2,718.366	136.481	1,997.144	2.5	907.733	167.189	1,051.357	5.0	13.0	3.09	1.26	5.6	26⅜–18¾	7.3
1980	2,485.226	114.000	1,889.679	2.0	872.656	229.163	1,009.746	4.6	11.3	2.60	1.20	6.0	25–15⅛	7.7
Philip A. Hunt Chemical Corp.														
1983	$119.939	$5.351	$90.676	2.6	$32.954	$5.235	$58.953	4.5%	9.1%	$0.94	$0.50	2.8%	$20½–15¾	19.3
1982	114.849	5.273	87.953	2.6	34.281	4.104	57.899	4.6	9.1	0.93	0.40	3.0	18–8⅝	14.3
1981	111.871	3.816[b]	87.238	2.6	36.231	9.105	56.005	3.4	6.8	0.67[b]	0.40	3.9	12⅛–8½	15.4
1980	106.296	4.044[c]	78.020	3.0	32.376	6.930	56.788	3.8	7.1	0.71[c]	0.40	3.5	14¼–8½	16.0
International Flavors & Fragrances														
1983	$460.945	$68.410	$458.262	3.5	$139.321	$26.851	$344.255	14.8%	19.9%	$1.87	$1.04	3.5%	$35¾–23¾	15.9
1982	447.889	63.160	431.589	4.1	135.565	28.369	335.902	14.1	18.8	1.73	1.01	4.3	30–17⅜	13.7
1981	451.088	66.123	430.890	3.8	125.975	16.558	329.878	14.7	20.0	1.81	0.94	4.6	23–17⅞	11.3
1980	448.309	63.232	414.859	3.8	121.228	17.461	315.485	14.1	20.0	1.73	0.86	3.9	27½–16⅝	12.8
International Minerals & Chemical Corp.														
1983[d]	$1,462.000	$ 80.500	$1,943.900	1.9	$1,983.700	$119.300	$1,024.100	5.5%	7.9%	$3.02	$2.60	6.5%	$ 49–31⅜	13.3
1982[d]	1,560.400	122.300[e]	1,941.900	1.8	1,869.900	161.600	1,010.200	7.8	12.1	4.56[e]	2.60	8.6	36⅞–23½	6.6
1981[d]	1,984.900	153.800	1,975.200	1.7	1,896.300	336.600	975.300	7.7	15.8	5.63	2.46	5.1	66½–30⅜	8.6
1980[d]	1,789.600	145.900	1,848.600	2.0	1,062.900	262.100	881.300	8.2	16.6	5.38	2.16	4.5	66½–30	9.0
Liquid Air Corp.														
1983	$459.409	$23.902	$500.573	1.5	$354.796	$41.620	$244.849	5.2%	9.8%	$1.80	$1.60	7.2%	$26¼–18½	12.4
1982	448.996	27.512	503.090	1.8	353.376	58.657	247.801	6.1	11.1	2.13	1.60	9.1	20¾–14¾	8.3
1981	427.991	31.526[f]	465.128	1.6	285.026	61.818	239.776	7.4	13.1	2.86[f]	1.55	6.7	29¾–16¾	8.1
1980	408.249	27.448[g]	425.502	1.6	270.778	60.469	202.832	6.7	13.5	2.57[g]	1.40	5.2	34½–19¾	10.6
Lubrizol Corp.														
1983	$789.546	$ 64.744[h]	$682.864	2.8	$274.337	$25.003	$471.521	8.2%	13.7%	$1.65	$1.08	4.7%	$27⅞–18⅛	13.9
1982	801.284	47.561	643.744	2.6	288.504	51.589	462.044	5.9	10.3	1.21	1.08	5.7	23¾–14¼	15.7
1981	878.291	92.031	673.165	2.6	284.088	75.399	478.518	10.5	19.2	2.36	1.08	3.9	35½–20⅜	11.8
1980	902.312	111.511	651.137	2.5	248.664	92.140	452.787	12.4	24.6	2.87	0.90	2.7	41¾–24⅞	11.6
Monsanto Co.														
1983	$6,299.000	$369.000[i]	$6,427.000	2.1	$3,284.000	$560.000	$3,667.000	5.9%	10.1%	$ 8.97[i]	$4.15	4.4%	$116⅜–74¼	10.6
1982	6,325.000	329.000[j]	6,077.000	2.4	3,313.000	673.000	3,490.000	5.2	9.4	8.21[j]	3.95	5.4	89–56⅝	8.9
1981	6,947.700	445.100[k]	6,069.200	2.2	3,183.900	667.900	3,330.200	6.4	13.4	11.50[k]	3.75	5.1	87½–59½	6.4
1980	6,573.600	148.800[l]	5,796.400	1.9	3,109.100	780.500	2,808.200	2.3	5.3	4.10[l]	3.55	6.3	70¼–42¼	13.7
Nalco Chemical Co.														
1983	$659.403	$71.000	$489.095	2.3	$191.791	$40.505	$350.471	10.8%	20.3%	$1.78	$1.14	3.5%	$ 37–28	18.3
1982	643.863	64.356[m]	464.868	2.2	194.450	56.241	336.488	10.0	19.1	1.62[m]	1.12	4.3	34–18	16.0
1981	666.591	81.209	466.175	2.2	176.959	59.423	335.974	12.2	24.2	2.02	1.00	4.0	29⅛–20½	12.3
1980	616.709	72.261	416.233	2.7	138.137	34.923	306.550	11.7	23.6	1.80	0.80	3.9	26⅝–14	11.2
Olin Corp.														
1983	$1,934.579	$71.715	$1,829.416	1.9	$850.936	$122.580	$848.355	3.7%	8.5%	$3.01	$1.23	4.3%	$ 34–23	9.5
1982	1,823.137	62.800[n]	1,636.027	1.7	839.974	139.015	805.185	3.4	7.8	2.66[n]	1.20	5.7	26¼–15½	7.8
1981	2,001.346	92.836	1,618.034	1.6	844.927	186.331	793.187	4.6	11.7	3.88	1.15	4.9	27–19½	6.0
1980	1,852.853	73.931[o]	1,550.128	1.7	822.412	172.016	750.120	4.0	9.9	3.08[o]	1.025	5.8	23⅞–12½	5.8
Pennwalt Corp.														
1983	$ 976.741	$44.796[p]	$851.982	2.6	$348.190	$69.808	$458.077	4.6%	9.8%	$3.58[p]	$2.20	5.9%	$45¾–29	10.4
1982	952.400	24.502[q]	737.048	1.6	342.785	76.466	346.364	2.6	7.1	2.37[q]	2.20	7.8	34⅞–21½	11.9
1981	1,056.118	36.661[r]	755.755	2.1	309.525	52.696	367.098	3.5	10.0	3.55[r]	2.20	7.1	36–26¼	8.8
1980	1,188.702	43.291	810.761	2.0	314.315	55.546	373.363	3.6	11.3	4.20	2.20	7.4	38⅜–25⅜	7.1
Reichhold Chemicals														
1983	$747.263	$21.700	$382.273	2.0	$175.722	$19.305	$211.081	2.9%	10.3%	$2.74	$0.51	1.8%	$38⅞–18¼	10.4
1982	814.911	6.875[s]	364.133	2.5	159.181	20.516	200.546	0.8	3.4	0.57[s]	0.48	3.2	19⅝–10	26.0
1981	950.112	17.054[t]	405.477	2.3	173.398	15.908	206.727	1.8	8.2	2.04[t]	0.48	3.5	16–11⅛	6.6
1980	885.059	16.114	424.760	2.1	179.550	22.656	203.941	1.8	7.9	1.90	0.61	5.0	15–9⅝	6.5
Rohm & Haas Co.														
1983	$1,875.937	$137.603	$1,511.244	2.7	$518.360	$ 71.534	$904.393	7.3%	15.2%	$5.33	$1.50	2.5%	$ 81–37¾	11.1
1982	1,828.027	85.605[u]	1,365.163	2.5	546.623	125.927	807.853	4.7	10.6	3.32[u]	1.40	4.5	39½–22¾	9.4
1981	1,884.664	93.085[v]	1,348.627	2.4	537.489	181.635	759.911	4.9	12.2	3.61[v]	1.28	4.3	35⅞–23⅜	8.2
1980	1,725.304	93.744	1,240.456	2.6	488.185	93.013	703.124	5.4	13.3	3.63	1.08	4.9	27⅝–16⅜	6.1

a Excludes extraordinary net gain on debt-for-equity exchange of $11.6 million ($0.25 per share). **b** From continuing operations; excludes net loss on disposal of photofinishing business of $146,000 ($0.03 per share). **c** From continuing operations; excludes net loss on operations and disposal of photofinishing business of $1.9 million ($0.33 per share). **d** Fiscal year ends June 30. **e** From continuing operations; excludes earnings and net gain on disposal of discontinued chemical operations of $15.1 million ($0.57 per share). **f** Includes net gain on sale of assets, before taxes, of $1.0 million. **g** Excludes net gain on sale of assets of $2.0 million ($0.19 per share). **h** Includes net gain on sale of investments of $7.5 million ($0.19 per share). **i** Excludes extraordinary net tax benefits from utilization of ex-U.S. loss carry-forwards of $33 million ($0.81 per share). **j** Excludes extraordinary net gain on debt-for-equity exchange of $23 million ($0.58 per share) but includes net loss on sale of European acrylic fibers business of $18 million ($0.46 per share). **k** Includes net gain on sale of joint venture of $67.7 million ($1.75 per share). **l** Includes net loss on withdrawal from polyester filament business in the U.S. of $69.0 million ($1.90 per share) and from termination of Aiscondel of $38.7 million ($1.07 per share). **m** Excludes net loss on discontinued Industrial Bio-Test Laboratories operations of $6.2 million ($0.16 per share). **n** Excludes special charge for DDT claims, net, of $9.5 million ($0.40 per share). **o** Excludes net charge for restructuring of Winchester group of $40.0 million ($1.07 per share). **p** Includes gain on sale, retirement, and revaluation of assets, before taxes, of $21.7 million. **q** From continuing operations; excludes provision for loss on disposal of discontinued operations of $2.8 million ($0.27 per share). **r** From continuing operations; includes cost of shutdown of chlorine-caustic plant, before taxes, of $21.5 million but excludes net loss on operations and disposal of discontinued businesses of $11.4 million ($1.10 per share) and nonrecurring net gain from cumulative effect of change in accounting for investment credit of $16.3 million ($1.57 per share). **s** Excludes net loss resulting from asset redeployment/divestiture program of $2.2 million ($0.32 per share). **t** Excludes extraordinary net charge for settlement of litigation of $2.4 million ($0.34 per share). **u** Includes net gain on shutdown and disposal of assets of $10.4 million ($0.40 per share). **v** Includes net loss from shutdown and disposal of assets of $6.6 million ($0.25 per share).

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
Money figures in thousands of dollars unless otherwise indicated														
Stauffer Chemical Co.														
1983[a]	$1,339,947	($12,348)[b]	$2,032,495	2.2	$1,128,752	$103,627	$1,009,297	...	...	($0.28)[b]	$1.44	5.3%	$31¾–22⅛	...
1982	1,618,235	123,547	2,170,162	2.5	1,200,576	176,872	1,065,751	7.6%	11.6%	2.81	1.41	6.2	28⅜–17	8.1
1981	1,726,236	150,093[c]	2,013,863	2.4	1,170,253	238,555	1,009,034	8.7	14.9	3.41[c]	1.29	5.5	27¾–18¾	6.8
1980	1,695,219	121,743[d]	2,084,441	1.4	1,072,896	246,454	909,490	7.2	13.4	2.77[d]	1.175	6.0	24⅜–14½	7.0
Stepan Chemical Co.														
1983	$207,074	$6,337	$144,997	1.5	$76,044	$ 9,804	$58,450	3.1%	10.8%	$1.75	$0.58	3.9%	$17½–12	8.4
1982	208,373	5,303	163,326	1.3	75,475	16,148	55,067	2.5	9.6	1.45	0.56	4.1	18⅛–9¼	9.4
1981	204,522	6,545[e]	176,068	1.5	67,906	12,083	53,888	3.2	12.1	1.74	0.515	3.0	21⅞–12⅜	9.8
1980	157,517	3,683[f]	137,688	1.5	64,338	9,204	50,498	2.3	7.3	0.98[f]	0.47	4.5	12¼–8½	10.5
Union Carbide Corp.														
1983	$ 9,001,000	$218,000[g]	$10,226,000	1.8	$6,282,000	$ 761,000	$4,860,000	2.4%	4.5%	$ 3.11[g]	$3.40	5.4%	$73⅞–51	20.1
1982	9,061,000	310,000	10,552,000	1.9	6,356,000	1,179,000	5,095,000	3.4	6.1	4.47	3.40	6.7	61–40⅛	11.3
1981	10,168,000	649,000	10,366,000	2.1	5,794,000	1,186,000	5,206,000	6.4	12.5	9.56	3.30	6.1	62⅛–45¼	5.6
1980	9,994,000	673,000[h]	9,600,000	2.1	5,207,000	1,129,000	4,717,000	6.7	14.3	10.08[h]	3.10	7.1	52½–35¼	4.4
Williams Cos.														
1983	$2,167,000	$ 54,000	$4,686,400	0.7	$3,193,000	$253,400	$1,173,900	2.5%	4.6%	$1.79	$1.20	5.1%	$30⅛–16¾	13.1
1982	1,691,315	29,682[i]	2,369,791	1.7	1,513,712	171,895	1,029,411	1.8	2.9	1.00[i]	1.20	5.6	29⅜–13⅛	21.2
1981	1,976,336	99,167[j]	2,445,877	1.6	1,497,797	233,184	1,027,245	5.0	9.7	3.32[j]	1.20	3.4	46⅝–23½	10.6
1980	2,072,686	138,696	2,380,001	1.8	1,417,799	339,625	965,715	6.7	14.4	5.07	1.10	2.9	49⅜–26¾	7.5
Witco Chemical Corp.														
1983	$1,385,744	$52,022	$715,472	2.1	$313,794	$44,901	$319,334	3.8%	16.3%	$3.60	$1.26	4.6%	$37¼–17⅜	7.6
1982	1,305,418	29,842	643,911	2.2	291,914	54,130	281,013	2.3	10.6	2.10	1.20	7.2	19⅝–13¾	8.0
1981	1,291,878	38,580	707,181	1.7	281,945	55,479	277,973	3.0	13.9	2.76	1.10	6.1	21–15⅛	6.6
1980	1,175,695	40,954	612,882	2.1	238,761	45,663	248,315	3.5	16.5	3.00	1.00	5.6	22½–13½	6.0
PHARMACEUTICALS														
Abbott Laboratories														
1983	$2,927,873	$347,617	$2,824,128	1.7	$1,069,200	$311,800	$1,417,883	11.9%	24.5%	$2.86	$1.00	2.2%	$55⅜–36⅛	15.6
1982	2,602,447	289,123	2,566,909	1.1	901,059	266,600	1,310,886	11.1	22.1	2.37	0.84	2.5	41¼–25⅜	14.1
1981	2,342,524	247,283	2,355,613	1.1	729,402	212,400	1,152,050	10.6	21.5	2.01	0.72	2.6	32¼–23⅝	13.9
1980	2,038,155	214,413	2,062,835	1.2	583,214	162,548	1,027,222	10.5	20.9	1.73	0.60	2.6	28½–17	13.2
American Home Products Corp.														
1983	$4,856,501	$627,233	$2,864,104	2.9	$812,370	$204,680	$1,826,964	12.9%	34.3%	$4.00	$2.40	5.0%	$54¼–41¾	12.0
1982	4,582,096	560,103	2,602,346	2.6	725,352	153,812	1,614,192	12.2	34.7	3.59	2.15	5.3	48–33¼	11.3
1981	4,131,237	497,332	2,517,541	3.0	492,879	99,852	1,583,475	12.0	31.4	3.18	1.90	5.8	37¼–28⅛	10.3
1980	3,798,524	445,889	2,289,460	2.8	450,490	99,393	1,391,972	11.7	32.0	2.84	1.70	6.4	31⅞–21⅜	9.4
Baxter Travenol Laboratories														
1983	$1,842,544	$218,055	$2,127,037	1.6	$746,304	$192,464	$1,151,109	11.8%	18.9%	$1.54	$0.28	1.1%	$31¼–20	16.6
1982	1,671,445	186,885	1,792,710	1.9	628,720	148,812	1,061,009	11.2	17.6	1.32	0.23	1.1	25½–15⅛	15.4
1981	1,503,890	150,581	1,590,743	2.6	583,084	87,101	978,325	10.0	15.4	1.07	0.19	1.3	16⅞–12	13.4
1980	1,374,384	128,400	1,412,638	2.8	560,690	118,645	852,506	9.3	15.1	0.93	0.16	1.4	14⅛–8⅞	12.4
Bristol-Myers Co.														
1983	$3,917,000	$408,000	$2,888,300	2.2	$701,700	$165,000	$1,788,900	10.4%	22.8%	$3.00	$1.16	2.9%	$47⅞–31¼	13.2
1982	3,599,900	348,700	2,665,800	2.2	653,600	170,000	1,624,000	9.7	21.5	2.59	1.02	3.3	37–25⅜	12.0
1981	3,496,700	305,800	2,406,000	2.2	581,800	159,300	1,482,000	8.7	20.6	2.29	0.89	3.4	29⅜–22⅞	11.4
1980	3,158,300	270,600	2,125,500	2.3	484,900	131,600	1,296,200	8.6	20.9	2.04	0.78	3.8	26–15¼	10.1
Eli Lilly & Co.														
1983	$3,033,700	$457,400	$3,413,800	1.7	$1,212,600	$199,900	$2,121,000	15.1%	21.6%	$6.13	$2.75	4.4%	$68⅜–56½	10.2
1982	2,962,711	411,828	3,155,125	1.8	1,135,575	236,642	2,055,460	13.9	20.0	5.42	2.60	4.7	65¼–45⅛	10.2
1981	2,773,205	374,478	2,902,262	1.9	1,006,180	253,735	1,888,260	13.5	19.8	4.93	2.375	4.2	68¾–45¼	11.6
1980	2,558,637	341,974	2,607,452	2.0	849,034	230,700	1,736,693	13.4	19.7	4.52	2.20	4.0	65½–45¾	12.3

[a] Fiscal year ends Sept. 30 (1983 only). [b] Net loss; excludes extraordinary net gains on refinancing of $10.6 million ($0.24 per share). [c] Excludes net loss on facility disposal and asset write-down of $169,000. [d] Excludes net gain on disposal of facilities of $14.8 million ($0.34 per share). [e] Includes loss on sale of flavor compounding business, before taxes, of $890,000. [f] Excludes net gain on sale of Polychem department of $1.7 million ($0.93 per share). [g] Excludes nonrecurring net charge for closing of facilities of $139 million ($1.98 per share). [h] Excludes cumulative effect of change in accounting principle for investment tax credit of $217 million ($3.28 per share). [i] From continuing operations; excludes net income from discontinued operations of $4.7 million ($0.15 per share). [j] From continuing operations; excludes net income from discontinued operations of $10.4 million ($0.35 per share).

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME % of sales	NET INCOME % of net worth	NET INCOME $ per share	Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
Merck & Co.														
1983	$3,246,139	$450,855	$4,214,698	1.7	$1,715,207	$272,756	$2,434,613	13.9%	18.5%	$6.10	$2.80	3.0%	$104⅝-81¾	15.3
1982	3,063,017	415,137	3,647,652	1.9	1,557,490	295,106	2,203,988	13.6	18.8	5.61	2.80	3.7	88¼-64	13.6
1981	2,929,455	398,265	3,310,000	1.7	1,395,567	322,814	2,001,460	13.6	19.9	5.36	2.60	2.9	103-76¼	16.7
1980	2,734,012	415,396	2,865,755	2.3	1,185,244	256,488	1,863,322	15.2	22.3	5.54	2.30	3.2	86-58¼	13.0
Pfizer														
1983	$3,750,000	$447,100	$3,830,000	2.0	$1,157,000	$214,900	$2,074,700	11.9%	21.6%	$2.73	$1.16	3.0%	$44¾-33⅝	14.4
1982	3,453,600	332,800	3,644,500	1.9	1,124,700	265,500	1,869,500	9.6	17.8	2.13	0.92	2.8	40⅜-25	15.3
1981	3,249,700	273,700[a]	3,544,200	1.9	998,200	287,100	1,594,700	8.4	17.2	1.82[a]	0.80	3.4	27½-20	13.1
1980	3,029,300	254,800	3,247,300	1.9	825,000	163,600	1,456,500	8.4	17.5	1.74	0.72	3.4	26⅞-16	12.3
Richardson-Vicks														
1983	$1,115,700	$51,400	$755,000	1.8	$241,600	$34,000	$264,900	4.6%	19.4%	$2.10	$1.48	5.6%	$29⅞-23⅜	12.7
1982[b]	1,115,600	66,900	687,100	2.0	247,000	57,500	394,600	6.0	17.0	2.74	1.48	5.6	32½-20½	9.7
1981[b]	1,088,100	83,200[c]	672,200	1.7	208,600	49,300	365,300	7.6	22.8	3.47[c]	1.32	4.7	34¾-21¾	8.1
1980[b,d]	1,211,651	84,209	829,551	2.0	242,568	52,630	427,938	6.9	19.7	3.56	1.20	4.3	38⅛-17½	7.8
A. H. Robins Co.														
1983	$563,510	$58,221[e]	$459,462	3.1	$107,651	$20,955	$305,636	10.3%	19.0%	$2.40	$0.62	2.7%	$29⅜-16	9.5
1982	482,324	48,693[f]	386,843	3.8	98,079	15,815	267,945	10.1	18.2	1.98[f]	0.52	3.3	20⅛-11¼	7.9
1981	450,854	44,228[g]	385,483	3.0	96,457	28,103	251,742	9.8	17.6	1.77[g]	0.44	3.8	14¾-8½	6.6
1980	432,328	25,470[h]	337,318	2.9	80,511	30,273	227,142	5.9	11.2	1.01[h]	0.42	4.4	12½-6⅝	9.5
Schering-Plough Corp.														
1983	$1,808,500	$178,500[i]	$2,309,800	1.3	$841,400	$177,700	$1,186,500	9.9%	15.0%	$3.40[i]	$1.68	4.0%	$48⅛-36¾	12.5
1982	1,817,900	183,500	2,341,200	1.8	747,500	180,400	1,278,500	10.1	14.4	3.39	1.68	4.8	40¾-26¼	10.3
1981	1,808,800	179,300	2,214,500	1.9	654,600	170,300	1,254,200	9.9	14.3	3.31	1.60	4.9	42½-24⅞	10.2
1980	1,740,400	239,300	1,925,800	1.7	524,800	130,900	1,193,800	13.7	20.0	4.45	1.56	4.2	45⅝-29⅛	8.4
G. D. Searle & Co.														
1983	$ 946,000	$119,000[j]	$1,278,100	2.3	$361,900	$124,800	$668,100	12.6%	17.8%	$2.39[j]	$0.52	1.1%	$55⅞-34¾	19.0
1982	1,036,900	140,400	1,204,500	2.1	377,800	135,200	599,700	13.5	23.4	2.77	0.52	1.4	45¼-28⅝	13.3
1981	942,300	130,900[k]	1,050,400	2.3	279,300	87,600	533,600	13.9	24.5	2.52[k]	0.52	1.7	35½-25⅛	12.0
1980	1,081,558	94,341[l]	1,089,920	1.4	249,695	66,961	508,844	8.7	18.5	1.78[l]	0.52	2.3	27⅝-17¼	12.6
SmithKline Beckman Corp.														
1983	$2,835,391	$485,990[m]	$3,085,409	1.8	$988,857	$232,914	$1,970,793	17.1%	24.7%	$5.85[m]	$2.65	4.0%	$76½-55¼	11.3
1982	2,968,667	455,157	2,765,900	2.1	971,302	304,784	1,749,407	15.3	26.0	5.51	2.39	3.5	77⅝-57⅜	12.3
1981	1,985,341	370,000	1,796,105	2.3	580,920	200,816	1,138,457	18.6	32.5	5.55	2.12	2.8	88⅜-63⅞	13.7
1980	1,771,938	307,994	1,490,914	2.4	421,788	132,806	923,723	17.4	33.3	4.65	1.725	2.8	80⅝-43½	13.3
Squibb Corp.														
1983	$1,768,891	$173,274[n]	$1,887,783	2.2	$564,613	$109,800	$1,173,399	9.8%	14.8%	$3.31[n]	$1.365	2.8%	$55⅝-42⅞	14.9
1982	1,660,766	153,636	1,871,882	2.1	511,821	87,280	1,037,989	9.3	14.8	3.01	1.28	3.2	50½-29	13.2
1981	1,523,911	41,098[o]	1,900,424	2.1	479,720	69,851	979,689	2.7	4.2	0.83[o]	1.215	3.8	37⅝-26⅝	38.7
1980	1,675,780	123,079[p]	1,858,270	2.3	600,895	89,032	964,504	7.3	12.8	2.56[p]	1.155	3.6	39¼-24⅜	12.4
Sterling Drug														
1983	$1,901,171	$136,844	$1,437,440	2.5	$366,328	$63,189	$879,655	7.2%	15.6%	$2.24	$1.11	4.3%	$29⅝-22⅛	11.6
1982	1,796,153	131,970	1,297,989	2.6	356,535	80,068	825,944	7.3	16.0	2.17	1.06	4.3	29⅝-19¾	11.4
1981	1,792,925	130,303	1,226,4[illegible]	2.5	334,980	77,016	787,542	7.3	16.5	2.15	0.98	4.3	26⅛-19	10.5
1980	1,701,433	123,337	1,214,2[illegible]	2.4	318,109	70,051	752,640	7.2	16.4	2.04	0.90	4.2	26⅞-16	10.5
Upjohn Co.														
1983	$1,986,106	$160,225	$2,195,048	1.9	$754,954	$155,016	$1,057,288	8.1%	15.2%	$5.28	$2.35	4.1%	$68¾-46¼	10.9
1982	1,828,730	126,020	2,013,985	1.9	675,869	137,273	973,028	6.9	13.0	4.18	2.28	4.7	59⅜-38	11.6
1981	1,898,334	181,764	1,940,485	2.0	614,481	139,211	965,267	9.6	18.8	6.04	2.07	3.6	69-45⅝	9.5
1980	1,760,576	170,375	1,669,621	1.9	544,322	109,800	865,753	9.7	19.7	5.71	1.93	3.5	68-41½	9.6
Warner-Lambert Co.														
1983	$3,108,325	$200,496	$2,368,879	1.7	$826,232	$165,854	$ 869,980	6.5%	23.0%	$2.51	$1.42	4.7%	$ 35-25¾	12.1
1982	3,245,967	174,970[q]	2,344,259	1.9	768,571	153,507	815,864	5.4	21.4	2.20[q]	1.40	5.6	30⅛-19⅝	11.3
1981	3,379,952	9,222[r]	2,662,418	1.7	869,753	165,833	1,084,796	0.3	0.9	0.12[r]	1.34	6.4	25-17⅛	175.5
1980	3,479,207	192,716[s]	2,638,077	2.1	827,131	138,688	1,171,477	5.5	16.5	2.41[s]	1.32	6.6	23¼-17	8.4

[a] From continuing operations; excludes net loss from discontinued diagnostic imaging operations and provision for loss on disposal of discontinued operations of $52.4 million ($0.34 per share). [b] Fiscal year ends June 30. [c] From continuing operations; excludes net loss from discontinued ethical pharmaceutical businesses of $3.9 million ($0.16 per share). [d] Data for Richardson-Merrell prior to sale (in March 1981) of ethical pharmaceutical businesses to Dow Chemical Co. [e] Includes income, before taxes, from litigation settlement of $2.3 million. [f] Includes income, before taxes, from litigation settlement of $3.1 million. [g] Includes income, before taxes, from litigation settlement of $3.4 million. [h] Includes income, before taxes, from litigation settlement of $3.6 million and provision for net losses on disposition of businesses of $4.7 million ($0.19 per share). [i] From continuing operations; excludes net gain on sale of discontinued home products business of $11.6 million ($0.22 per share). [j] From continuing operations; excludes gain on sale of Pearl Health Services shares of $39.0 million but excludes net income and gain on sale of discontinued specialty gas and Australian specialty chemical operations of $32.2 million ($0.65 per share). [k] From continuing operations; excludes net loss from operations and disposition of discontinued businesses of $26.0 million ($0.50 per share) and debit for cumulative effect of changes in accounting principles of $6.2 million ($0.12 per share). [l] From continuing operations; excludes reserve for loss on sale of assets of diagnostic business of $9.0 million ($0.17 per share) and extraordinary tax credit of $13.0 million ($0.24 per share). [m] From continuing operations; excludes net income of discontinued Industrial Business Group of $3.5 million ($0.04 per share). [n] Excludes extraordinary net gain on early extinguishment of debt of $27.0 million ($0.52 per share) and net loss on disposal of Latin American operations of $27.6 million ($0.53 per share). [o] From continuing operations; excludes net gain on sale of confectionery products business of $58.1 million ($1.16 per share), net income from that business of $12.2 million ($0.24 per share), and extraordinary charge relating to takeover of operations in Iran of $6.5 million ($0.13 per share). [p] From continuing operations; excludes net income of divested food services and related operations of $4.3 million ($0.09 per share). [q] Includes nonrecurring net credit of $12 million ($0.15 per share). [r] Includes nonrecurring net charge of $134 million ($1.68 per share). [s] Includes nonrecurring net charge of $3 million ($0.03 per share).

3 *Efficiency in the U.S. Chemical Industry*

Productivity up as capacity use improves

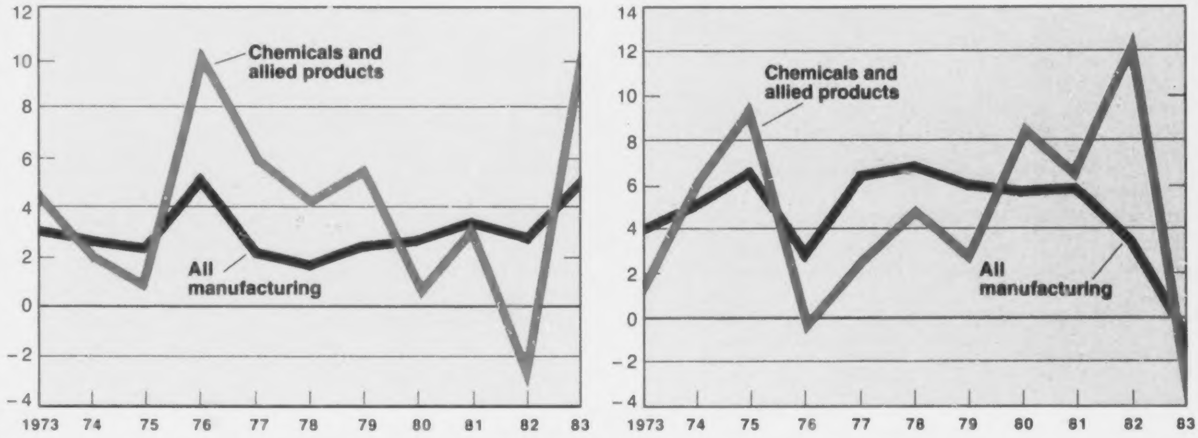
Many measures of chemical productivity took a postrecession turn in 1983, improving over the year before. An increase in output, coupled with lower employment, had a lot to do with it. But also, companies are working to increase efficiency, which is starting to pay off.

The result is that productivity for chemicals and allied products increased more than twice as fast as it did for all manufacturing. And labor costs also declined much faster for chemicals than for manufacturing as a whole.

Production of chemicals climbed 10% in 1983, whereas for all manufacturing it rose 8%. At the same time, total workhours per week fell 0.5% for chemicals while they were rising 2.3% for all manufacturing. However, wages for production personnel rose a more rapid 6% in the chemical industry but only 4% for all manufacturing.

Thus, productivity (output per workhour) increased nearly 11% for chemicals and allied products, more than double the increase of 5% for all manufacturing. This follows a decline of 3.2% in 1982 for chemicals and a rise of 2.6% for manufacturing. Unit labor costs fell 4% last year for chemicals but only 1% for all manufacturing. The year before, unit labor costs for chemicals rose 13%.

Chemical capacity use also began to rebound in 1983. The latest C&EN survey for basic chemicals shows plants operating at 72% of capacity in early 1984 as opposed to 64% the year before.


A surge in labor productivity last year . . . **. . . brought unusual cut in unit labor costs**

Note: Productivity is output per workhour, calculated by dividing indexes for production by indexes for workhours of production employees. Unit labor costs are labor costs per unit of output, calculated by dividing indexes for wages by indexes for output per workhour. **Sources:** Department of Labor, Federal Reserve Board, C&EN estimates

PRODUCTIVITY: A big increase for chemical companies in 1983 after 1982's slump

Indexes, 1967 = 100	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
CHEMICALS & ALLIED PRODUCTS											
Production	215.8	196.1	215.6	206.6	210.4	197.4	185.7	170.9	147.2	159.4	154.4
Workhours	99.1	99.6	105.9	105.1	107.4	106.5	104.2	101.4	96.5	105.1	103.7
Productivity	217.8	196.9	203.5	196.6	195.9	185.4	178.3	168.6	152.6	151.7	149.0
Hourly production wages	341.6	321.3	294.2	267.7	245.2	226.5	207.4	190.6	173.9	157.4	145.5
Unit labor costs	156.8	163.2	144.6	136.2	125.1	122.1	116.3	113.1	113.9	103.8	97.6
ALL MANUFACTURING											
Production	148.3	137.6	150.4	146.6	153.2	146.8	138.4	130.3	116.3	129.4	129.8
Workhours	87.6	85.6	96.0	97.0	104.1	102.5	98.0	94.2	88.6	100.9	104.0
Productivity	169.2	160.8	156.7	151.2	147.1	143.3	141.2	138.3	131.2	128.2	124.8
Hourly production wages	313.5	301.4	283.3	257.8	237.6	218.8	201.4	185.1	171.3	156.7	145.0
Unit labor costs	185.3	187.5	180.8	170.5	161.5	152.7	142.7	133.9	130.5	122.3	116.3

Sources: Department of Labor, Federal Reserve Board, C&EN calculations

OPERATING RATES: Capacity use is rising but early this year remained below 1981 levels

Billions of lb per year unless otherwise noted[a]	1ST-QTR 1984		3RD-QTR 1983		1ST-QTR 1983		3RD-QTR 1982		1ST-QTR 1982		3RD-QTR 1981	
	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use
ORGANIC CHEMICALS												
Benzene (bg)	2.4	51%	2.3	60%	2.3	43%	2.4	48%	2.4	44%	2.7	67%
Butadiene[c]	4.5	51	4.5	58	4.5	37	4.4	40	4.6	42	4.6	67
Cyclohexane	3.4	62	3.4	52	3.4	31	3.1	37	3.1	33	3.4	59
DMT-TPA[d]	7.6	82	7.6	80	7.3	64	7.3	56	7.3	58	7.3	71
Ethylene	36.5	82	38.4	74	39.0	67	39.0	61	39.7	56	41.0	65
Formaldehyde, 37% solution	9.2	56	9.2	56	9.2	55	8.9	47	8.9	51	8.9	65
Methanol (bg)	1.9	60	1.8	63	1.7	56	1.6	76	1.5	72	1.4	83
Phenol	3.3	85	3.3	83	3.6	64	3.6	61	4.0	56	4.0	67
Propylene, chemical	23.0	59	23.0	61	23.0	49	23.0	56	23.0	44	23.5	59
Styrene	7.8	92	8.1	77	8.2	64	8.7	69	8.7	79	8.9	74
Urea (mt)	7.8	83	7.8	59	7.8	73	7.8	72	7.8	65	8.0	90
Vinyl acetate	2.4	87	2.4	83	2.4	90	2.3	91	2.4	72	2.4	79
Vinyl chloride	10.0	54	9.3	79	10.1	65	10.0	68	9.6	50	9.7	70
p-**Xylene**	4.9	85	4.9	93	4.9	68	4.9	60	5.5	54	5.6	64
INORGANIC CHEMICALS												
Ammonia (mt)	17.8	88	18.7	64	18.7	71	19.8	82	19.8	84	24.0	80
Carbon black	3.3	86	3.3	73	3.3	63	3.4	62	3.4	75	3.4	82
Carbon dioxide (ttd)[e]	19.0	67	19.6	64	18.9	61	18.4	67	17.7	63	16.4	71
Caustic soda (mt)	14.3	68	15.5	66	15.4	66	15.6	61	15.7	59	15.5	75
Chlorine (mt)	13.4	72	14.5	70	14.4	66	14.6	64	14.8	62	14.8	78
Nitrogen **Oxygen** } total, liquid (ttd)	39.4	61	40.0	64	37.0	64	36.6	65	37.6	64	36.0	66
Phosphoric acid, (P_2O_5) (mt)[f]	12.5	82	12.5	66	12.5	71	12.6	64	12.4	62	11.5	91
Phosphorus (mt)	0.55	67	0.55	67	0.55	82	0.55	68	0.55	66	0.55	78
Soda ash (mt)	11.0	77	10.7	81	10.7	74	10.9	73	10.4	76	10.0	83
Sulfuric acid (mt)	58.0	66	57.5	52	57.5	59	59.6	49	59.4	54	58.5	74
Titanium dioxide (mt)	0.90	84	0.91	86	1.0	60	1.0	61	1.0	53	1.0	82
AVERAGE		72%		**69%**		**63%**		**62%**		**60%**		**74%**

a bg = billions of gallons, mt = millions of tons, ttd = thousands of tons per day. **b** Nameplate capacity. **c** Total extraction capacity, which runs about 25% more than basic production capacity. **d** Dimethyl terephthalate-purified terephthalic acid, not including acid converted to dimethyl terephthalate. **e** Excludes oil field operations. **f** Includes both wet-process and furnace-process capacity. **Sources:** Industry and government sources, C&EN estimates

Excess capacity less a problem for chemical process industries in 1983

	Operating rate, % of nameplate capacity, as of December										
	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
Chemicals	71%	65%	69%	80%	83%	83%	79%	78%	77%	72%	84%
Paper	96	86	85	93	94	92	89	85	85	78	95
Rubber	93	75	75	81	83	89	87	85	79	74	94
Petroleum	71	72	77	77	87	93	91	93	88	89	93
Textiles	89	75	75	83	91	88	87	81	88	67	93
All manufacturing	79	69	74	81	85	87	83	81	77	75	87

Source: Federal Reserve Board

ENERGY USE BY CHEMICAL INDUSTRY: Total use declines, led by cuts in natural gas

	1983		1982		1981		1980		1972		Change 1972–83	
Energy source[a]	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	**994**	**37.5%**	**1051**	**38.7%**	**1272**	**40.2%**	**1293**	**39.7%**	**1570**	**47.3%**	**−576**	**−36.7%**
Purchased electricity[b]	**803**	**30.3**	**811**	**29.9**	**931**	**29.4**	**943**	**29.0**	**732**	**22.1**	**71**	**9.7**
Petroleum-based fuels	**451**	**17.0**	**472**	**17.4**	**542**	**17.1**	**621**	**19.1**	**592**	**17.8**	**−141**	**−23.8**
Light hydrocarbons[c]	301	11.3	325	12.0	351	11.1	380	11.7	333	10.0	−32	−9.6
Residual fuels	90	3.4	88	3.2	104	3.3	141	4.3	161	4.8	−71	−44.1
Distillate fuels	12	0.5	14	0.5	18	0.6	23	0.7	34	1.0	−22	−64.7
Other fuel[d]	47	1.8	45	1.7	70	2.2	77	2.4	65	1.9	−18	−27.7
Coal and coke	**318**	**12.0**	**295**	**10.9**	**324**	**10.2**	**301**	**9.3**	**294**	**8.9**	**24**	**8.2**
Purchased steam	**85**	**3.2**	**83**	**3.1**	**98**	**3.1**	**95**	**2.9**	**128**	**3.9**	**−43**	**−33.6**
TOTAL	**2652**	**100.0%**	**2712**	**100.0%**	**3167**	**100.0%**	**3255**	**100.0%**	**3316**	**100.0%**	**−664**	**−20.0%**

a For energy and process use only, excluding energy equivalent of feedstock. **b** Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. **c** Includes propane, liquefied petroleum gas, and other gases. **d** Includes petroleum coke, gasoline, and other liquids and solids. **Note:** Data from companies accounting for about 90% of U.S. capacity for basic industrial chemicals. **Source:** Chemical Manufacturers Association

ENERGY USE BY FERTILIZER INDUSTRY: Total is down sharply for the second year

	1983		1982		1981		1980		1972		Change 1972–83	
Energy source[a]	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	**125.6**	**77.6%**	**151.8**	**76.8%**	**200.6**	**81.2%**	**205.0**	**79.3%**	**161.3**	**79.3%**	**−35.7**	**−22.1%**
Purchased electricity[b]	**31.9**	**19.7**	**33.7**	**17.1**	**43.7**	**17.7**	**46.9**	**18.2**	**35.3**	**17.4**	**−3.4**	**−9.6**
Petroleum-based fuels	**0.4**	**0.3**	**4.4**	**2.3**	**1.8**	**0.7**	**5.8**	**2.2**	**6.2**	**3.1**	**−5.8**	**−92.8**
Residual fuels	0.4	0.2	4.4	2.2	1.0	0.4	4.5	1.7	3.8	1.9	−3.5	−90.7
Distillate fuels	na	na	na	na	0.7	0.3	0.7	0.3	2.2	1.1	na	na
Other fuel[c]	0.1	0.1	0	0	0.2	0.1	0.6	0.2	0.2	0.1	−0.1	−48.9
Coal and coke	**na**	**na**	**na**	**na**	**0.5**	**0.2**	**0.6**	**0.2**	**0.5**	**0.2**	**na**	**na**
Generated steam[d]	**3.9**	**2.4**	**7.6**	**3.8**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**
Purchased steam	**0**	**0**	**0**	**0**	**0.4**	**0.1**	**0.2**	**0.1**	**0.1**	**0**	**−0.1**	**100**
TOTAL	**161.8**	**100.0%**	**197.6**	**100.0%**	**246.9**	**99.9%**	**258.5**	**100.0%**	**203.3**	**100.0%**	**−41.5**	**−20.4%**

a For energy and process use only, excluding energy equivalent of feedstock. **b** Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. **c** Includes propane, liquefied petroleum gas, gasoline, diesel oil, kerosine, and other fuels. **d** Steam generated from fossil fuel, listed prior to 1982 under residual fuels, distillate fuels, other fuel, and coal and coke. **na** = not available. **Note:** Data from companies accounting for more than 70% of U.S. ammonia capacity. **Source:** Fertilizer Institute

ENERGY USE BY PETROLEUM INDUSTRY: Two thirds comes from petroleum itself

	1983		1982		1981		1980		1972		Change 1972–83	
Energy source[a]	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	**565**	**22.3%**	**591**	**22.4%**	**686**	**24.7%**	**734**	**25.1%**	**951**	**33.6%**	**−386**	**−40.6%**
Purchased electricity[b]	**244**	**9.6**	**242**	**9.1**	**250**	**9.0**	**253**	**8.6**	**186**	**6.6**	**58**	**31.2**
Petroleum-based fuels	**1696**	**66.9**	**1781**	**67.5**	**1810**	**65.1**	**1903**	**65.1**	**1655**	**58.4**	**41**	**2.5**
Light hydrocarbons[c]	1118	44.1	1189	45.0	1194	43.0	1243	42.5	985	34.8	133	13.5
Residual fuels	134	5.3	149	5.6	177	6.4	215	7.3	240	8.5	−106	−44.2
Petroleum coke	433	17.1	429	16.2	428	15.4	425	14.5	407	14.4	26	6.4
Other fuel[d]	11	0.4	15	0.5	11	0.4	19	0.7	23	0.8	−12	−52.2
Coal and coke	**7**	**0.3**	**6**	**0.2**	**5**	**0.2**	**4**	**0.1**	**5**	**0.2**	**2**	**40.0**
Purchased steam	**23**	**0.9**	**20**	**0.8**	**28**	**1.0**	**31**	**1.1**	**35**	**1.2**	**−12**	**−34.3**
TOTAL	**2534**	**100.0%**	**2640**	**100.0%**	**2779**	**100.0%**	**2925**	**100.0%**	**2832**	**100.1%**	**−298**	**−10.5**

a For energy and process use only, excluding energy equivalent of feedstock. **b** Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. **c** Includes propane, liquefied petroleum gas, and refinery gas. **d** Includes distillate fuels, gasoline, and other liquids. **Note:** Data from companies accounting for about 85% of U.S. petroleum refining capacity, including Puerto Rico. **Source:** American Petroleum Institute

Little growth yet for chemical workforce

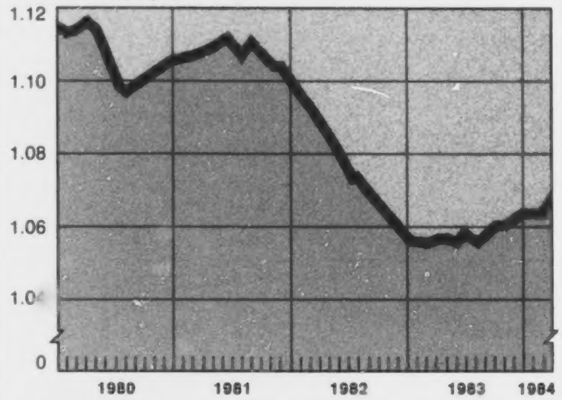
In 1983, the number of workers employed by the U.S. chemical industry hovered near 1,058,000—well below 1982 and the lowest level of employment since 1976. The steep drop in jobs throughout 1982 bottomed out, however. Moreover, the second half of 1983 and early 1984 show a small but steady trend toward higher employment rates.

Although the chemical industry as a whole had a net loss of jobs in 1983, compared to 1982, the chemical products sector added employees. Manufacturers of drugs, soaps and toiletries, and paints increased the number of both supervisory and production workers during the year. It is interesting that production workers in these fields earn lower wages than the industry average. The highest-paid workers are in sectors that lost production jobs during 1983—industrial inorganic and organic chemicals.

Major chemical firms continued to cut workforces in 1983, though not so severely as in 1982. But some of the smaller employers, among them International Flavors, Olin, and Pennwalt, added employees.

Employment in the chemical industry remained near four-year low through 1983

Millions of employees[a]



a Seasonally adjusted employment in U.S. chemicals and allied products industry; March and April 1984 figures are preliminary. **Source:** Department of Labor

INDUSTRIAL EMPLOYMENT: Still below 1981 levels for most of chemical industry

	All employees[a] (thousands)				Production workers[a] (thousands)				Workweek[a,b] (hours)			
	1983	1982	1981	1973	1983	1982	1981	1973	1983	1982	1981	1973
All manufacturing	18,678	18,853	20,170	20,154	12,696	12,790	14,020	14,834	40.1	38.9	39.8	40.7
Chemicals and allied products	1,058	1,079	1,109	1,038	588	601	628	610	41.6	40.9	41.6	41.8
Industrial inorganic chemicals	153	160	162	143	78	85	88	88	41.5	40.4	41.5	42.1
Plastics materials and synthetics	179	186	196	242	116	120	130	160	42.0	40.6	42.0	41.7
Drugs	201	199	199	161	99	98	99	83	41.0	41.1	41.1	41.7
Soap, cleaners, and toilet goods	151	146	146	126	94	92	92	72	41.1	40.6	40.4	40.8
Paints and allied products	62	61	63	69	30	29	31	39	40.9	39.6	40.4	41.4
Industrial organic chemicals	162	171	178	147	83	86	90	78	42.5	41.9	42.8	42.7
Agricultural chemicals	61	65	70	59	37	40	44	37	42.1	42.0	43.0	42.5
Miscellaneous chemical products	90	91	94	90	51	51	54	54	41.3	40.5	41.3	41.6
Petroleum and coal products	196	201	214	193	118	120	134	124	43.9	43.9	43.2	42.4
Rubber and miscellaneous plastics products	727	701	737	692	562	536	569	547	41.2	39.6	40.3	41.1

a Domestic employment. b Workweek of production or nonsupervisory workers. **Source:** Department of Labor

EMPLOYMENT OF SCIENTISTS, ENGINEERS: Climbs to new high in chemicals

Thousands[a]	1983[b]	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
Total, all industry	535.6	509.8	487.8	450.6	423.9	404.4	382.8	364.4	363.3	360.0	357.7
Chemicals and allied products	67.1	61.6	54.7	51.4	50.0	48.3	46.4	44.4	45.2	41.8	40.9
Industrial chemicals	26.4	25.9	21.6	20.9	21.4	21.3	20.6	20.1	21.1	19.1	19.1
Drugs and medicines	30.0	25.6	23.3	21.6	20.8	19.5	17.8	16.6	15.6	14.0	13.0
Other chemicals	10.7	10.1	9.8	8.9	7.8	7.5	8.0	7.8	8.5	8.7	8.8
Petroleum refining	15.1	15.6	13.0	10.8	10.1	9.9	8.9	8.6	8.4	8.2	8.2
Rubber products	na	8.1	10.3	na	8.1	7.9	9.1	8.6	8.4	7.7	7.5

a Full-time-equivalent number of R&D scientists and engineers in industry, as of January of each year. b Preliminary. **na** = not available separately but included in total. **Source:** National Science Foundation

CHEMICAL EMPLOYMENT: Down for third straight year in 1983

Thousands	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Air Products	16.7	18.9	16.2	15.8	14.6	14.3	13.7	13.4	13.0	13.0
American Cyanamid	38.7	40.2	41.8	42.6	44.2	44.0	43.8	39.4	37.8	38.0
Celanese	23.3	25.3	35.9	36.5	33.3	33.2	32.1	31.9	37.0	38.8
Crompton & Knowles	2.4	2.3	2.5	2.8	3.0	3.2	3.1	3.0	2.2	2.4
Dow Chemical	54.5	56.6	63.8	56.8	55.9	53.5	53.2	53.0	53.0	53.3
Ethyl	13.0	14.0	14.5	15.0	16.0	16.5	16.0	16.0	17.0	18.0
Freeport-McMoRan	4.8	5.0	5.2	2.7	3.9	3.5	3.7	3.8	3.5	3.3
H. B. Fuller	4.1	4.0	3.3	3.4	3.4	3.3	3.0	2.8	2.6	2.3
W. R. Grace	78.5	82.2	89.0	91.7	82.1	68.5	68.7	63.8	65.3	79.1
Hercules	24.2	24.5	22.8	22.9	24.4	24.5	24.0	24.0	23.5	25.3
International Flavors	3.7	3.6	3.6	3.6	3.6	3.5	3.3	3.1	2.9	3.1
International Minerals	8.4	8.4	10.6	10.6	10.3	9.9	9.9	9.7	10.5	6.6
Lubrizol	4.2	4.3	4.2	4.2	3.9	3.8	3.6	3.6	3.6	3.5
Monsanto	50.9	51.2	57.4	61.8	63.9	62.9	61.5	61.9	59.2	60.9
Nalco Chemical	4.6	4.6	4.7	4.4	4.1	4.1	4.2	3.8	3.5	3.4
Olin	18.2	17.5	20.3	21.0	21.7	22.7	22.4	22.0	23.0	23.0
Pennwalt	9.8	9.5	10.7	12.8	13.3	14.0	13.9	13.9	14.3	14.8
PPG Industries	37.0	37.0	36.6	37.3	38.2	37.4	36.6	36.3	34.9	38.0
Reichhold Chemicals	3.6	4.5	5.6	5.6	6.4	6.5	6.5	5.8	4.3	4.1
Rohm & Haas	11.4	11.5	13.5	13.2	13.3	13.1	13.0	13.3	13.8	14.2
Stauffer Chemical	9.7	11.0	12.2	13.4	13.8	13.1	13.0	13.0	13.1	12.5
Stepan Chemical	0.9	0.9	0.9	0.8	0.9	0.8	0.8	0.7	0.7	0.8
Union Carbide	99.5	103.2	110.3	116.1	115.8	113.4	113.7	113.1	106.5	109.6
TOTAL EMPLOYEES	**522.0**	**540.3**	**585.6**	**595.0**	**590.0**	**569.7**	**563.7**	**551.3**	**545.2**	**568.0**
ANNUAL CHANGE	−3.4%	−7.7%	−1.6%	0.8%	3.6%	1.1%	2.2%	1.1%	−4.0%	4.9%
SALES PER EMPLOYEE ($ thousands, current)	**$116.6**	**$110.7**	**$110.9**	**$103.5**	**$95.8**	**$91.1**	**$74.7**	**$68.8**	**$51.3**	**$57.5**
SALES PER EMPLOYEE ($ thousands, constant 1972[a])	**$ 41.5**	**$ 39.5**	**$ 40.2**	**$ 41.4**	**$44.9**	**$47.8**	**$40.4**	**$38.3**	**$29.5**	**$40.8**

[a] Based on producer price index for chemicals and allied products. **Note:** Data for years prior to 1982 are not restated for acquisitions and similar adjustments.

WAGES: Workers in the chemical industry earn more than average for all industry

	Hourly earnings[a]				Weekly earnings[a]			
	1983	1982	1981	1973	1983	1982	1981	1973
All manufacturing	$ 8.84	$ 8.50	$ 7.99	$4.09	$354.48	$330.65	$318.00	$166.46
Chemicals and allied products	10.59	9.96	9.12	4.51	440.54	407.36	379.39	188.52
Industrial inorganic chemicals	11.72	11.02	10.16	4.88	486.38	445.21	421.64	205.45
Plastics materials and synthetics	10.55	9.87	9.01	4.31	443.10	400.72	378.42	179.73
Drugs	9.70	9.08	8.29	4.34	397.70	373.19	340.72	180.98
Soap, cleaners, and toilet goods	9.67	9.13	8.38	4.41	397.44	370.68	338.55	179.93
Paints and allied products	9.33	8.80	8.03	4.24	381.60	348.48	324.41	175.54
Industrial organic chemicals	12.73	11.85	10.72	5.22	541.03	496.52	458.82	222.89
Agricultural chemicals	10.31	9.71	8.89	4.06	434.05	407.82	382.27	172.55
Miscellaneous chemical products	9.65	9.22	8.44	4.32	398.55	373.41	348.57	179.71
Petroleum and coal products	13.28	12.46	11.91	5.28	582.99	546.99	491.62	223.87
Rubber and miscellaneous plastics products	8.02	7.65	7.17	3.81	330.42	302.94	288.95	156.59

[a] For production and nonsupervisory workers in domestic employment. **Source:** Department of Labor

Foreign Trade 5

U.S. chemical surplus continues to narrow

Nobody really believes that growth in world chemical trade has come to an end. But, based on the record, scattered doubts are understandable.

Last year, world chemical trade, measured as exports, dropped 6% to $127.8 billion for the third decline in a row. This is a dramatic reversal from the past; world chemical trade grew an average 21% per year between 1970 and 1980. Given the improved economic outlook in most of the world's industrialized nations, world chemical trade probably will revert to growth again this year. But it will be several years before it returns to its 1980 record level of $147 billion.

Virtually all of the world's major chemical exporting countries suffered a drop in chemical shipments last year. The U.S. was no exception.

The U.S. chemical trade surplus took another nosedive last year, not only because chemical exports dropped but also because chemical imports surged. The drop in exports was only slight—less than 1% to $19.75 billion. By comparison, the jump in chemical imports was an astonishing 14%, topping the $10 billion mark for the first time and setting a new record at $10.8 billion.

As a result, the chemical industry's treasured trade surplus shrank 14% from $10.4 billion to $9.0 billion. That's the third successive decline for the U.S. chemical trade surplus, dropping it to the lowest that it has been since 1978.

Chemical imports, of course, benefited from the strong U.S. economy and from an all-too-strong U.S. dollar. The strong dollar makes imports very competitive with domestic products.

On the other hand, U.S. chemical exports were hurt by the strong U.S. dollar. The economic recovery in other countries also has lagged that in the U.S. As a result, overseas demand for U.S. chemicals wasn't strong. Meanwhile, the staggering debts of many developing nations make it difficult, if not impossible, for them to do much importing.

U.S. TOTAL TRADE BALANCE:
The deficit grows ominously

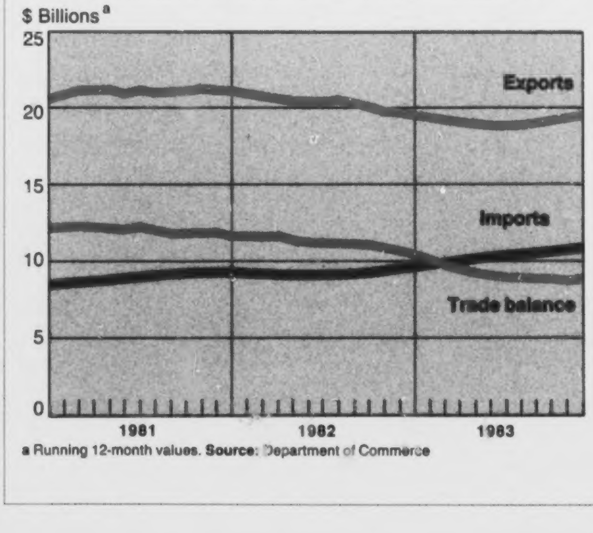
$ Billions	1983	1982	1981	1973
Exports	$200.5	$212.2	$233.7	$70.8
Imports	258.0	244.0	261.0	69.5
Trade balance	−57.5	−31.8	−27.3	1.3

Source: Department of Commerce

U.S. CHEMICAL TRADE BALANCE:
The surplus is dwindling

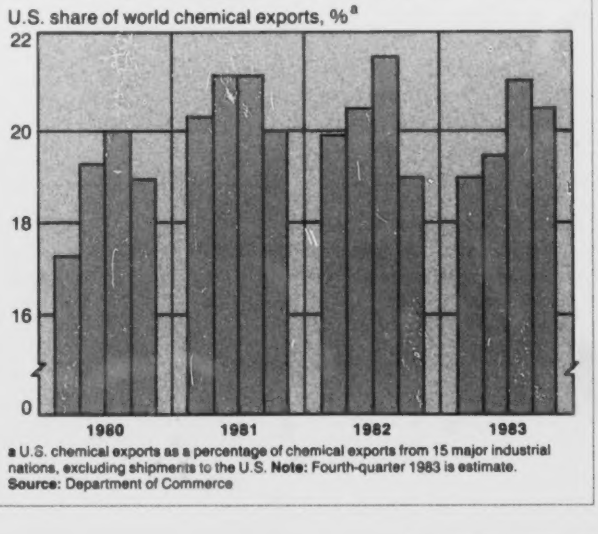
$ Millions	1983	1982	1981	1973
Chemical exports	$19,751	$19,891	$21,187	$5748
Chemical imports	10,779	9,494	9,446	2437
Chemical trade balance	8,972	10,397	11,741	3311

Import rise cuts chemical trade balance . . .



a Running 12-month values. **Source:** Department of Commerce

. . . but U.S. clings to fifth of world markets



a U.S. chemical exports as a percentage of chemical exports from 15 major industrial nations, excluding shipments to the U.S. **Note:** Fourth-quarter 1983 is estimate. **Source:** Department of Commerce

WORLD TRADE: Recession cuts exports

$ Millions	1983	1982	1981	1973
CHEMICAL EXPORTS				
World	$127,800[a]	$136,500[a]	$142,983	$40,315
U.S.	19,751	19,891	21,187	5,748
Canada	3,603	3,406	4,002	753
EC, 10 countries	60,653	67,598	69,452	22,558
Belgium-Luxembourg	5,807	6,173	6,477	2,313
France	9,830	11,708	12,141	3,524
Italy	4,619	5,296	5,214	1,652
Netherlands	9,318	9,982	10,418	3,413
U.K.	7,978	10,687	10,831	3,120
West Germany	20,623	21,185	21,966	7,944
Switzerland	5,546	5,440	5,505	2,021
Japan	6,983	6,365	6,841	2,147
CHEMICAL IMPORTS				
U.S.	10,779	9,494	9,446	2,437
Canada	3,973	3,310	3,569	1,230
EC, 10 countries	49,765	50,226	51,483	16,022
Belgium-Luxembourg	5,158	5,143	5,235	1,664
France	9,473	9,898	10,376	3,112
Italy	7,250	6,890	7,020	2,263
Netherlands	5,353	5,473	5,726	1,911
U.K.	6,799	7,318	7,260	2,200
West Germany	12,190	12,031	12,201	3,572
Switzerland	3,300	3,208	3,226	1,141
Japan	7,207	6,824	6,487	1,865

a C&EN estimates. **Sources:** United Nations, Organization for Economic Cooperation & Development, European Communities, individual country data

U.S. TRADE: Developing areas buy less

$ Millions	1983	1982	1981	1973
U.S. CHEMICAL EXPORTS				
Canada	$ 2,546	$ 2,183	$ 2,478	$ 844
Western Europe	5,892	5,940	6,155	1,905
Eastern Europe	306	366	347	30
Communist Asia	353	497	406	8
Japan	2,607	2,530	2,349	629
Rest of Asia	2,859	2,600	2,597	575
Middle East	423	533	517	119
Latin America	3,273	3,670	4,469	1,165
Australasia	696	655	778	212
Africa	492	524	642	172
Other	304	393	449	89
TOTAL	**$19,751**	**$19,891**	**$21,187**	**$5,748**
U.S. CHEMICAL IMPORTS				
Canada	$2,390	$2,596	$2,916	$ 554
Western Europe	5,020	4,174	3,931	1,186
Eastern Europe	197	151	131	19
Communist Asia	131	136	126	8
Japan	1,099	879	956	239
Rest of Asia	283	220	197	36
Middle East	113	99	110	13
Latin America	924	613	669	94
Australasia	234	286	186	151
Africa	227	225	117	22
Other	161	115	107	115
TOTAL	**$10,779**	**$9,494**	**$9,446**	**$2,437**

Source: Department of Commerce

U.S. TRADE, BY PRODUCTS: Plastics and drugs buck general decline in exports

	Chemical exports				Chemical imports			
$ Millions	1983	1982	1981	1973	1983	1982	1981	1973
Organic chemicals	$ 5,326	$ 5,440	$ 5,929	$1582	$ 3,477	$2960	$2974	$ 636
Inorganic chemicals	1,838	1,969	2,286	544	1,615	1502	1573	523
Radioactive and associated materials	1,213	1,132	988	284	952	1143	786	151
Dyeing, tanning, and coloring materials	163	162	175	90	300	213	226	111
Pigments, paints, and varnishes	328	332	349	126	145	103	102	21
Medicinals and pharmaceuticals	2,494	2,275	2,165	626	703	563	583	164
Flavors, perfumes, cosmetics, and toiletries	493	514	535	141	370	295	289	125
Cleaning and polishing materials	295	324	396	122	90	76	74	19
Fertilizers, manufactured	1,267	1,386	1,735	407	997	963	1181	280
Explosives and pyrotechnics	87	90	90	31	64	67	61	27
Plastics and resins	3,732	3,650	3,809	1028	1,098	766	780	207
Pesticides and disinfectants	630	607	544	a	251	265	283	a
Miscellaneous chemical products	1,885	2,010	2,187	767	717	579	534	174
TOTAL	**$19,751**	**$19,891**	**$21,187**	**$5748**	**$10,779**	**$9494**	**$9446**	**$2437**

a Included in miscellaneous. **Source:** Department of Commerce

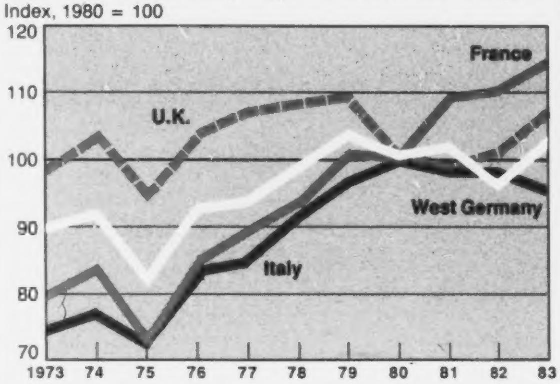
Foreign Chemical Industries-Western Europe

6

West European chemical industry executives are justifiably pleased with 1983's business outcome. Sales were up nearly everywhere. More to the point, many companies registered significant gains in earnings. Only one major company, Italy's Montedison, lost money, but even it trimmed its loss to less than half what it had been in 1982. France's Rhône-Poulenc turned the corner into profitability following three years in the red.

Several factors contributed to higher profits. Operating economies that had been introduced during the two previous years began to pay off last year. An upswing in demand coupled with earlier plant shutdowns raised the operating rates of plants that were running. And prices firmed, particularly for commodity chemicals.

France leads, Italy lags in chemical output



CHEMICAL INDUSTRY TRENDS: Currency weaknesses undercut growth in dollar values

$ Billions (U.S.)	1983	1982	1981	1980	1979
WEST GERMANY					
Sales	$ 49.7	$ 48.5	$ 51.6	$ 59.2	$ 56.0
Exports	24.0	22.9	23.8	26.0	24.0
Imports	13.6	13.0	13.3	14.6	13.2
Capital spending	2.7	2.8	3.1	3.8	3.3
Production index (1980 = 100)	103.4	96.4	101.6	100.0	104.3
Price index (1980 = 100)	113.9	113.7	108.7	100.0	92.7
Employees (thousands)	549	559	548	550	547
FRANCE					
Sales	$ 30.6	$ 30.4	$ 33.4	$ 37.3	$ 32.9
Exports	11.5	11.2	11.9	13.0	11.5
Imports	8.9	9.1	9.2	10.4	8.9
Capital spending	1.0	1.1	1.2	1.6	1.4
Production index (1980 = 100)	114.9	110.2	108.8	100.0	95.6
Price index (1980 = 100)	139.0	127.5	114.2	100.0	84.0
Employees (thousands)	275	286	289	296	301
U.K.[a]					
Sales	$ 27.2	$ 28.2	$ 37.6	$ 41.0	$ 35.6
Exports	10.5	11.5	12.3	12.3	10.4
Imports	7.8	8.2	7.9	7.3	7.2
Capital spending	1.2	1.9	2.5	3.2	2.5
Production index (1980 = 100)	106.6	100.8	98.7	100.0	108.5
Price index (1980 = 100)	119.0	113.5	106.3	100.0	86.4
Employees (thousands)	327	338	395	430	441
ITALY					
Sales	$ 22.1	$ 22.7	$ 24.1	$ 28.7	$ 23.7
Exports	5.7	5.0	5.6	5.9	5.2
Imports	7.9	7.4	7.8	9.0	7.9
Capital spending	1.1	1.1	1.1	1.9	1.7
Production index (1980 = 100)	95.1	98.3	98.1	100.0	96.4
Price index (1980 = 100)	134.9	124.1	111.9	100.0	82.9
Employees (thousands)	251	260	271	289	291
SPAIN					
Sales	$ 14.2	$ 15.2	$ 15.7	$ 17.3	$ 15.4
Exports	2.2	2.2	2.3	2.5	2.0
Imports	2.8	2.9	3.1	3.5	3.1
Capital spending	0.3	0.4	0.4	0.7	0.6
Production index (1980 = 100)	104.5	100.0	98.3	100.0	102.9
Price index (1980 = 100)	147.4	131.0	116.9	100.0	83.8
Employees (thousands)	242	243	244	244	245
BELGIUM					
Sales	$ 13.2	$ 14.1	$ 15.3	$ 16.6	$ 14.4
Exports	8.8	8.9	9.2	10.4	9.3
Imports	6.3	6.3	6.4	7.5	6.6
Capital spending	0.3	0.3	0.4	0.5	0.5
Production index (1980 = 100)	108.1	103.1	101.1	100.0	105.6
Price index (1980 = 100)	133.7	126.0	110.7	100.0	88.4
Employees (thousands)	88	88	88	90	82
NETHERLANDS					
Sales	$ 13.1	$ 12.5	$ 13.6	$ 14.3	$ 13.5
Exports	12.0	11.3	11.9	13.0	11.8
Imports	6.8	6.7	7.1	7.9	7.0
Capital spending	0.7	0.6	0.6	0.7	0.6
Production index (1980 = 100)	110.0	100.0	97.7	100.0	103.0
Price index (1980 = 100)	115.0	114.0	114.4	100.0	91.2
Employees (thousands)	88	90	91	91	92
SWITZERLAND					
Sales	$ 6.7	$ 6.6	$ 6.7	$ 6.8	$ 6.6
Exports	5.5	5.4	5.4	5.6	5.3
Imports	3.3	3.3	3.3	3.7	3.2
Production index (1980 = 100)	109.6	103.0	104.2	100.0	97.6
Price index (1980 = 100)	106.4	106.8	104.9	100.0	93.5
Employees (thousands)	68	na	63	62	62
SWEDEN					
Sales	$ 4.0	$ 4.0	$ 4.1	$ 4.3	$ 3.9
Exports	1.8	1.6	1.6	1.7	1.5
Imports	2.7	2.6	2.5	2.9	2.7
Capital spending	0.2	0.3	0.3	0.4	0.4
Production index (1980 = 100)	116.5	104.8	109.4	100.0	115.2
Price index (1980 = 100)	135.5	120.4	108.8	100.0	87.5
Employees (thousands)	44	44	41	39	40
NORWAY					
Sales	$ 2.0	$ 2.0	$ 1.9	$ 2.1	na
Exports	1.1	1.0	1.5	1.2	$ 0.9
Imports	0.9	0.9	1.0	1.1	1.0
Capital spending	0.1	0.1	0.1	0.2	0.1
Production index (1980 = 100)	104.0	100.6	101.7	100.0	90.0
Price index (1980 = 100)	123.6	117.9	112.5	100.0	80.9
Employees	19	18	17	17	17

a Excludes fibers. **na** = not available. **Sources:** National chemical federations and Conseil Européen des Fédérations de l'Industrie Chimique

MAN-MADE FIBERS: Output of noncellulosics bounced back in 1983

Millions of lb	1983		1982		1981		1980		1979		Change, 1982-83	
	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics
West Germany	1667	331	1511	315	1735	322	1619	304	1725	295	10%	5%
Italy	1166[b]	65	1091[b]	102	1115[b]	133	896[b]	144	988	156	7	−36
U.K.	541[c]	330[d]	506[c]	263[d]	612[c]	298[d]	700[c]	364[d]	838	504	7	25
Spain	539	70	507	95	518	111	452	116	466	128	6	−26
France	436	83	434	100	444	119	423	146	493	169	0	−17
Switzerland	203	0	183	0	197	0	186	4	185	7	11	—
Benelux countries	183	134	198	124	228	144	230	148	286	165	−8	8
Austria	53	251	51	251	53	257	56	255	62	242	4	0
Ireland	na	0	114	0	110	0	92	0	86	0	—	—
Portugal	na	na	99	3	75	9	67	6	68	7	—	—

a Excludes polypropylene filament unless otherwise indicated. **b** Includes polypropylene filament. **c** Includes cellulose acetate filament. **d** Excludes cellulose acetate filament. **na** = not available.
Source: Comité International de la Rayonne et des Fibres Synthétiques

PRODUCTION: Volume was up from 1982, but often not to earlier levels

Millions of lb	1983	1982	1981	1980	Change 1982-83
FRANCE					
Sulfuric acid	9024	8858	9917	10,894	2%
Hydrochloric acid	1483	1514	1544	1,487	−2
Chlorine	2872	2759	2711	2,765	4
Sodium hydroxide	3064	2939	2893	2,946	4
Ammonia	4312	4180	4950	4,587	3
Benzene	1373	1133	1100	1,204	21
Toluene	90	69	124	140	30
Xylenes	199	113	251	172	76
Ethylene	4563	4112	4085	4,561	11
Propylene	2455	2277	2212	2,174	8
Butadiene	620	569	586	572	9
Formaldehyde	208	175	220	254	19
Methanol	761	753	765	757	1
Polyethylenes	2070	1938	1944	2,364	7
Polypropylene	842	692	656	464	22
Polystyrene	734	680	577	559	8
Polyvinyl chloride	1796	1729	1563	1,596	4
Synthetic rubber	1125	1045	1070	1,124	8
Phosphate fertilizers (P_2O_5)	1577	2447	2590	2,965	−36
ITALY					
Sulfuric acid	4999	5150	5597	6,220	−3%
Nitric acid	2289	2265	2212	2,232	1
Phosphoric acid	816	932	979	1,044	−12
Chlorine	1958	1592	1556	1,821	23
Sodium hydroxide	2229	1868	1857	2,097	19
Ammonia	2636	2709	3239	3,770	−3
Benzene	1142	841	932	939	36
Toluene	660	587	613	631	12
Xylenes	742	594	564	625	25
Ethylene	2126	1918	2011	2,364	11
Propylene	1017	978	1083	1,426	4
Butadiene	429	350	366	403	23
Phthalic anhydride	299	299	309	310	0
Formaldehyde	250	224	240	288	12
Acetic acid	241	347	401	430	−31
Carbon black	319	334	337	378	−4
Polyethylenes	1456	1159	1223	1,645	26
Polystyrene	710	667	637	714	6
Polyvinyl chloride	1457	1292	1282	1,480	13
Synthetic rubber	501	475	535	569	5
U.K.					
Sulfuric acid	5787	5692	6360	7,440	2%
Hydrochloric acid[a]	259	260	257	302	0
Nitric acid	6890	6784	6541	6,215	2
Chlorine	1977	1935	1916	2,004	2
Benzene	1743	1399	1799	1,978	25
Ethylene	2540	2454	2718	2,409	3
Propylene	1719	1695	1621	1,260	1
Butadiene	523	503	457	422	4
Acetone	268	298	245	270	−10
Formaldehyde	226	236	249	273	−4
Phenol	315	308	241	310	2
Polyethylenes	900	937	1000	957	−4
Polypropylene	506	487	435	418	4
Polystyrene	301	254	302	345	18
Synthetic rubber	571	537	493	466	6
Nitrogen fertilizers (N)[a]	3148	2777	2784	2535	13
Phosphate fertilizers (P_2O_5)[a]	962	838	842	835	15
WEST GERMANY					
Sulfuric acid	8107	8334	9018	9,054	−3%
Hydrochloric acid	1980	1865	1953	1,960	6
Nitric acid	5778	5040	6356	6,994	15
Chlorine	6900	6253	6629	6,592	10
Sodium hydroxide	6830	6318	6687	6,595	8
Sodium sulfate	297	472	561	496	−37
Sodium carbonate	2678	2432	2616	3,104	10
Ammonia	4495	4145	5179	5395	8
Benzene	2939	2258	2027	2,022	30
Toluene	691	590	578	573	17
Xylenes	1127	1012	1071	783	11
Ethylene	6980	5808	6357	6,744	20
Propylene	3793	3259	3550	3,501	16
Butadiene	1580	1275	na	na	24
Ethylene oxide	993	866	955	847	15
Ethylene glycol	451	404	487	459	12
Acetaldehyde	692	571	670	736	21
Acetic acid	590	562	646	631	5
Ethanol	172	220	222	238	−22
Formaldehyde	1144	1070	1117	1,059	7
Methanol	1470	1559	1524	1,810	−6
Phthalic anhydride	429	439	474	494	−2
Polyethylenes	2997	2473	2639	3,080	21
Polyvinyl chloride	2398	1902	2021	2,097	26
Synthetic rubber	951	888	914	900	7
Nitrogen fertilizers (N)	1639	1464	2191	2,449	12
Phosphate fertilizers (P_2O_5)	571	595	732	841	−4

a Manufacturers' sales. **na** = not available. **Sources:** Government agencies for each country

COMPANY RESULTS: Profits recover but capital outlays and employment generally fall

$ Millions	Net sales	Net income	Profit margin	Capital spending	R&D spending	Employees (thousands)
Bayer (West Germany)						
1983	$14,641.6	$295.7	2.0%	$ 734.1	$664.3	174.8
1982	14,335.0	26.3	0.2	846.6	637.9	179.4
1981	14,930.1	228.8	1.5	1123.5	622.1	180.9
1980	15,837.9	401.1	2.5	1461.0	681.9	181.6
Hoechst (West Germany)						
1983	$14,583.9	$356.5	2.4%	$ 733.3	$634.1	179.8
1982	14,397.5	130.5	0.9	850.6	642.4	182.2
1981	15,236.7	188.5	1.2	870.4	670.4	184.7
1980	16,436.8	305.5	1.9	1053.8	714.8	186.9
BASF (West Germany)						
1983	$13,769.0	$202.7	1.5%	$ 639.2	$466.3	114.1
1982	13,368.7	113.2	0.8	824.3	483.1	115.9
1981	14,055.8	162.4	1.2	911.1	484.1	116.6
1980	15,236.8	197.3	1.3	1011.5	545.6	116.5
Imperial Chemical Industries (U.K.)						
1983	$12,528.1	$602.4[a]	4.8%	$ 547.8	$418.8	117.9
1982	12,886.2	253.9	2.0	511.4	427.3	123.8
1981	13,348.9	389.5[b]	2.9	833.7	464.5	132.4
1980	13,290.7	302.3[c]	2.3	1683.7	493.0	143.2
Ciba-Geigy (Switzerland)						
1983	$7,019.5	$369.5	5.3%	$395.2	$594.3	79.2
1982	6,802.0	306.4	4.5	427.6	578.8	79.4
1981	6,938.3	265.8	3.8	446.4	549.0	80.2
1980	7,134.1	182.6	2.6	510.8	561.1	81.1
Montedison (Italy)						
1983	$7,017.8	($207.4)[d,e]	—	$295.6	$171.2	72.8
1982	6,665.9	(529.9)[d,f]	—	324.5	170.7	84.2
1981	7,851.3	(564.6)[d]	—	377.3	175.0	94.2
1980	9,090.0	(523.4)[d]	—	450.9	205.6	105.5
DSM (Netherlands)						
1983	$6,937.9	$57.5	0.8%	$212.3	$61.4	27.9
1982	6,806.0	(70.3)[d]	—	165.5	63.7	28.6
1981	7,330.4	40.4	0.6	196.8	64.0	30.0
1980	7,496.5	12.6	0.2	258.3	75.4	31.4
Rhône-Poulenc (France)						
1983	$5,658.4	$ 12.9	0.2%	$365.6	$288.7	80.0
1982	5,661.5	(128.5)[d]	—	329.7	267.6	81.8
1981	6,604.6	(61.6)[d]	—	447.8	279.8	89.3
1980	7,156.2	(461.4)[d]	—	613.0	323.9	95.4
Akzo (Netherlands)						
1983	$5,293.0	$189.1[g]	3.6%	$219.3	$217.5	66.3
1982	5,301.1	85.0[h]	1.6	273.4	232.2	73.7
1981	5,790.4	95.6[i]	1.6	277.2	234.0	77.8
1980	6,257.8	89.9[j]	1.4	324.1	258.8	83.1

$ Millions	Net sales	Net income	Profit margin	Capital spending	R&D spending	Employees (thousands)
Norsk Hydro (Norway)						
1983	$4,077.9	$66.8	1.6%	$525.6	na	18.8
1982	3,185.9	24.2	0.8	509.3	na	19.6
1981	3,045.6	65.0	2.1	370.7	na	15.1
1980	2,854.0	80.0	2.8	326.3	na	13.5
Solvay (Belgium)						
1983	$3,887.0	$128.3[k]	3.3%	$155.3	$127.1	44.2
1982	3,891.3	47.6[l]	1.2	153.8	131.1	45.4
1981	4,239.7	(9.9)[d,m]	—	247.6	143.4	48.2
1980	4,734.9	79.9[n]	1.7	368.0	154.0	49.1
Hoffmann-La Roche (Switzerland)						
1983	$3,576.2	$156.4	4.4%	$216.1	$473.5	45.9
1982	3,499.2	138.5	4.0	346.7	453.5	46.5
1981	3,456.4	129.1	3.7	308.6	414.2	44.0
1980	3,506.5	138.9	4.0	309.0	415.0	43.6
Sandoz (Switzerland)						
1983	$3,117.1	$152.4	4.9%	$128.6	$261.9	38.1
1982	2,981.8	134.5	4.5	124.6	244.8	37.3
1981	2,941.8	115.8	3.9	155.6	236.2	36.4
1980	2,934.1	121.0	4.1	153.9	248.5	35.5
BOC International (U.K.)						
1983	$2,582.1	$ 83.2[o]	3.2%	$468.1	na	39.1
1982	2,686.9	113.0[p]	4.2	388.3	na	38.4
1981	3,086.6	93.9[q]	3.0	316.0	na	42.1
1980	2,777.9	92.6[r]	3.3	319.3	na	44.7
Albright & Wilson (U.K.)						
1983	$ 865.3	$31.9[s]	3.7%	$37.2	na	6.3
1982	929.6	12.4[t]	1.3	33.6	na	7.2
1981	1,019.9	9.3[u]	0.9	51.7	na	8.9
1980	986.0	(5.1)[d,v]	—	70.5	na	9.2
UCB (Belgium)						
1983	$572.4	$22.0[w]	3.6%	$23.5	$17.6	6.4
1982	606.6	9.4	1.6	20.0	17.2	6.7
1981	686.0	4.3	0.6	31.0	18.7	7.8
1980	786.4	8.1	1.0	38.2	21.9	8.1
Fisons (U.K.)						
1983	$ 554.5	$38.1[x]	6.9%	$4.7	$21.2	5.8
1982	613.8	25.4	4.1	3.2	29.4	7.5
1981	1,002.8	7.8	0.8	3.9	31.2	9.8
1980	1,055.1	(3.3)[d]	—	4.9	32.6	11.3
Laporte Industries (U.K.)						
1983	$440.4	$27.7[y]	6.3%	$ 7.7	na	3.5
1982	425.5	19.3[z]	4.6	21.7	na	3.5
1981	435.5	12.8	2.9	20.3	na	3.9
1980	457.0	7.4	1.6	37.2	na	4.7

a Excludes nonrecurring net loss of $28.8 million. **b** Excludes nonrecurring net loss of $12.2 million. **c** Excludes nonrecurring net loss of $348.8 million. **d** Deficit. **e** Excludes minority interests' loss of $4.6 million. **f** Excludes nonrecurring loss of $105.7 million and gain from minority interests of $0.7 million. **g** Excludes nonrecurring net loss of $35.8 million. **h** Excludes nonrecurring net loss of $18.4 million. **i** Excludes nonrecurring net gain of $2.8 million. **j** Excludes nonrecurring net loss of $123.6 million. **k** Excludes nonrecurring net loss of $25.7 million. **l** Excludes nonrecurring net gain of [illegible] million. **m** Excludes nonrecurring net loss of $10.3 million. **n** Excludes nonrecurring net loss of $11.3 million. **o** Excludes nonrecurring net loss of $19.4 million. **p** Excludes nonrecurring net gain of $10.7 million. **q** Excludes nonrecurring net gain of $1.2 million. **r** Excludes nonrecurring net loss of $24.7 million. **s** Excludes nonrecurring net gain of $1.5 million. **t** Excludes nonrecurring net loss of $17.2 million. **u** Excludes nonrecurring net gain of $1.8 million. **v** Excludes nonrecurring net loss of $7.9 million. **w** Excludes nonrecurring net loss of $3.0 million. **x** Excludes nonrecurring net loss of $10.0 million. **y** Excludes nonrecurring net loss of $3.5 million. **z** Excludes nonrecurring net gain of $138.4 million. **na** = not available.

NOTE ON CURRENCY CONVERSION

For monetary statistics in this section, European currencies were converted to U.S. dollars by the following conversion rates:

$1.00 (U.S.) is equivalent to:

	Belgium	France	Italy	Netherlands	Norway	Spain	Sweden	Switzerland	U.K.	West Germany
1983	51.13 francs	7.62 francs	1519 lire	2.85 guilders	7.30 crowns	143.43 pesetas	7.67 crowns	2.10 francs	0.659 pound	2.55 marks
1982	45.69 francs	6.57 francs	1353 lire	2.67 guilders	6.45 crowns	109.86 pesetas	6.28 crowns	2.03 francs	0.571 pound	2.43 marks
1981	37.13 francs	5.44 francs	1137 lire	2.50 guilders	5.74 crowns	92.31 pesetas	5.06 crowns	1.96 francs	0.493 pound	2.26 marks
1980	29.24 francs	4.23 francs	856 lire	1.99 guilders	4.94 crowns	71.71 pesetas	4.23 crowns	1.67 francs	0.430 pound	1.82 marks
1979	29.32 francs	4.25 francs	831 lire	2.01 guilders	5.06 crowns	67.12 pesetas	4.29 crowns	1.66 francs	0.471 pound	1.83 marks

6 *Foreign Chemical Industries-Japan*

Japanese chemical firms are not yet completely healthy, but they are no longer candidates for an intensive care unit. The long-awaited economic recovery finally has arrived and, with it, chemical company fortunes are looking up. Domestic demand has increased, so that companies now are able to push through price increases and make them stick. Exports once more are increasing, and competition from imports has eased.

All of this means higher profits for Japan's troubled chemical companies, which seem to have been hit harder by the 1979 oil crisis than they were by the crisis in 1973. To be sure, profit margins still are low, but there isn't so much red ink now as there was previously.

Output of most chemicals is increasing. One indicator: Ethylene production last year increased almost 3% after three successive years of decline.

WORLD TRADE: **Chemical deficit continues**

$ Millions	1983	1982	1981	1980
Total exports	$146,927	$138,831	$152,030	$129,807
Total imports	126,393	131,931	143,290	140,528
Chemical exports	6,983	6,365	6,841	6,767
Chemical imports	7,207	6,824	6,487	6,202

Source: Ministry of International Trade & Industry

INDUSTRY TRENDS: **Modest gain in 1983**

Index, 1980 = 100	1983	1982	1981	Change 1982-83
All chemicals				
Production	108.8	102.5	99.8	6%
Shipments	104.6	98.9	98.0	6
Inventories	92.3	98.1	99.7	−6
Petrochemicals				
Production	98.5	92.4	94.5	7
Shipments	97.9	92.7	95.0	6
Inventories	86.7	94.1	93.8	−8
Plastics				
Production	105.2	96.5	95.4	9
Shipments	104.5	96.1	95.7	9
Inventories	88.9	90.9	95.6	−2
Synthetic fibers				
Production	97.1	96.0	97.9	1
Shipments	98.6	97.0	100.0	2
Inventories	126.6	121.5	105.6	4
Synthetic rubber				
Production	91.6	85.1	92.3	8
Shipments	91.9	85.8	93.1	7
Inventories	80.9	91.4	94.8	−11
Fertilizer				
Production	77.4	80.2	84.6	−3
Shipments	78.0	82.2	84.5	−5
Inventories	72.3	85.5	104.5	−15
All manufacturing				
Production	104.9	101.4	101.0	3
Shipments	103.4	99.9	100.6	3
Inventories	96.3	101.5	102.1	−5

Source: Ministry of International Trade & Industry

PRODUCTION: **Generally higher last year**

Thousands of metric tons unless otherwise indicated	1983	1982	1981	1980	Change 1982-83
ORGANIC CHEMICALS					
Acetaldehyde	255	279	324	432	−9%
Acetic acid	328	353	365	418	−7
Acetone	247	229	225	235	8
Acrylonitrile	459	489	477	469	−6
Benzene	1750	1588	1690	1847	10
Butadiene	556	522	518	574	7
Butyl alcohol	229	228	237	222	0
Caprolactam	395	388	427	443	2
Cyclohexane	454	426	475	500	7
Dioctylphthalate	231	221	223	241	5
Ethylene	3684	3590	3655	4176	3
Ethylene dichloride	1736	1548	1650	2060	12
Ethylene glycol	357	385	411	492	−7
Ethylene oxide	468	471	478	529	−1
Methanol, refined	373	625	734	836	−40
Octyl alcohol, synthetic	219	226	239	241	−3
Phenol, synthetic	271	211	214	215	28
Phthalic anhydride[a]	161	159	164	142	1
Propylene	2632	2565	2538	2636	3
Propylene glycol	194	185	171	163	5
Styrene	1184	1086	1095	1114	9
Terephthalic acid	702	649	635	601	8
Toluene	831	803	821	885	3
Toluene diisocyanate	74	67	64	67	10
Urea	980	1187	1483	1770	−17
Xylene	1264	1225	1202	1195	3
INORGANIC CHEMICALS					
Ammonium chloride	435	486	584	683	−10
Ammonium sulfate	1722	1689	1817	1879	2
Calcium carbide	476	483	495	550	−1
Calcium superphosphate	559	527	483	591	6
Carbon black	568	504	557	575	13
Chlorine, liquid	818	794	764	763	3
Hydrochloric acid	511	551	565	570	−7
Nitrogen, millions of cu m	5369	5236	5147	4586	3
Oxygen, millions of cu m	6434	6493	6603	6854	−1
Sodium carbonate	1103	1162	1178	1357	−5
Sodium hydroxide	2863	2792	2872	3159	3
Sodium silicate	588	650	692	712	−10
Sulfuric acid	6662	6530	6572	6777	2
Titanium dioxide	196	184	176	173	7
PLASTICS					
Phenolic resins	303	281	294	304	8
Polyethylene	1773	1674	1671	1860	6
Polypropylene	1062	941	959	927	13
Polystyrene	1311	1190	1183	1129	10
Polyvinyl chloride	1420	1218	1129	1429	17
DYES, synthetic	55	54	50	51	2
RUBBER CHEMICALS, organic	42	39	43	46	8
RUBBER, synthetic	1002	931	1010	1094	8

a Petroleum-based only. **Source:** Ministry of International Trade & Industry

COMPANY RESULTS: Higher sales help to bolster profits

$ Millions	Sales	Net income	Profit margin	Total assets	Employees (thousands)
Mitsubishi Chemical Industries[a]					
1983	$3127	0.0	—	$3479	8.5
1982	3142	($36.5)[b]	—	3326	8.4
1981	3399	13.5	0.4%	3374	8.3
1980	3730	39.8	1.1	3739	8.0
Asahi Chemical Industry					
1983	$2958	$46.5	1.6%	$3023	16.3
1982	2670	45.8	1.7	2809	14.0
1981	2663	48.4	1.8	2895	13.6
1980	2800	64.4	2.3	2825	13.6
Sumitomo Chemical[c]					
1983	$2746	0.0	—	$2775	7.9
1982	2681	($30.6)[b]	—	2510	9.1
1981	2881	10.5	0.4%	2699	9.6
1980	3167	45.0	1.4	2856	9.7
Toray Industries					
1983	$2577	$59.2	2.3%	$2576	14.1
1982	2398	59.4	2.5	2385	13.9
1981	2503	48.3	1.9	2446	13.9
1980	2494	57.9	2.3	2408	13.8
Teijin					
1983	$1817	$48.6	2.7%	$1846	7.1
1982	1751	30.1	1.7	1953	7.1
1981	2072	24.1	1.2	2090	7.2
1980	2111	28.3	1.3	2093	7.3
Dainippon Ink & Chemicals					
1983	$1707	$19.0	1.1%	$1472	6.0
1982	1609	17.9	1.1	1426	5.9
1981	1657	18.8	1.1	1511	5.9
1980	1654	22.1	1.3	1448	5.8
Mitsui Toatsu Chemicals					
1983	$1606	($29.6)[b]	—	$1794	5.4
1982	1783	44.9	2.5%	1790	5.7
1981	1948	(22.3)[b]	—	1858	7.4
1980	1965	(32.8)[b]	—	1941	7.7
Mitsubishi Petrochemical[c]					
1983	$1521	0.0	—	$1644	2.5
1982	1508	($37.4)[b]	—	1767	3.5
1981	1667	(6.3)[b]	—	1802	3.9
1980	1900	16.2	0.9%	1908	3.8
Showa Denko[c]					
1983	$1479	($12.7)[b]	—	$2086	5.0
1982	1539	(2.9)[b]	—	2004	5.3
1981	1729	2.6	0.2%	2102	5.4
1980	2083	35.7	1.7	2276	5.5
Sekisui Chemical					
1983	$1373	$15.2	1.1%	$1199	6.1
1982	1294	9.0	0.7	1238	6.2
1981	1338	7.9	0.6	1322	6.1
1980	1420	17.0	1.2	1359	6.1
Unitika					
1983	$1206	0.0	—	$1146	6.4
1982	1045	($18.6)[b]	—	1113	6.2
1981	965	0.4	0.0%	1135	6.2
1990	1011	4.1	0.4	1229	6.3
Mitsui Petrochemical Industries					
1983	$1166	$ 6.3	0.5%	$1392	4.3
1982	1200	(7.1)[b]	—	1412	4.5
1981	1260	(8.6)[b]	—	1455	4.6
1980	1339	10.8	0.8	1474	4.6

$ Millions	Sales	Net income	Profit margin	Total assets	Employees (thousands)
Toyo Soda Mfg.					
1983	$930	$ 16.9	1.8%	$1133	3.9
1982	883	(10.7)[b]	—	1131	4.3
1981	927	(60.4)[b]	—	1209	4.9
1980	942	5.2	0.6	1251	5.0
Mitsubishi Gas Chemical					
1983	$923	$11.4	1.2%	$891	3.8
1982	909	9.9	1.1	884	3.8
1981	931	20.8	2.2	938	3.8
1980	898	30.7	3.4	948	3.8
Kyowa Hakko Kogyo[c]					
1983	$921	$21.5	2.3%	$836	5.1
1982	915	21.0	2.3	802	5.0
1981	928	18.8	2.0	782	4.9
1980	945	14.9	1.6	749	5.0
Mitsubishi Rayon					
1983	$908	$13.5	1.5%	$884	3.7
1982	841	9.9	1.2	824	3.6
1981	894	11.0	1.2	803	3.5
1980	882	11.1	1.3	814	3.5
Kuraray					
1983	$862	$5.1	0.6%	$943	6.4
1982	821	4.3	0.5	904	6.3
1981	879	8.2	0.9	928	6.3
1980	956	7.5	0.8	984	5.7
Hitachi Chemical					
1983	$824	$11.0	1.3%	$489	4.5
1982	751	8.5	1.1	465	4.4
1981	753	9.9	1.3	451	4.3
1980	746	8.2	1.1	440	4.3
Kanegafuchi Chemical Industry					
1983	$773	$13.1	1.7%	$597	2.9
1982	673	8.3	1.2	546	3.3
1981	719	5.9	0.8	583	3.2
1980	776	13.3	1.7	612	3.1
Japan Synthetic Rubber					
1983	$761	$9.7	1.3%	$678	2.7
1982	699	7.5	1.1	709	2.7
1981	737	3.0	0.4	720	2.7
1980	779	8.2	1.1	761	2.6
Shin Etsu Chemical[d]					
1983	$756	$20.3	2.7%	$609	2.5
1982	668	18.4	2.8	601	2.5
1981	674	8.5	1.3	629	2.4
1980	653	11.5	1.8	600	2.3
Tokuyama Soda					
1983	$718	$6.8	0.9%	$691	2.4
1982	695	5.5	0.8	669	2.5
1981	768	4.4	0.6	691	2.5
1980	767	5.2	0.7	682	2.4
Daicel Chemical					
1983	$697	$14.8	2.1%	$643	3.1
1982	654	12.9	2.0	634	3.1
1981	702	12.5	1.8	656	3.1
1980	677	12.6	1.9	659	3.1

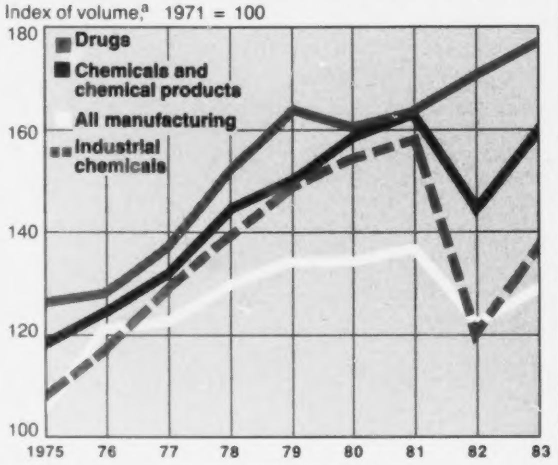
a Fiscal year ends Jan. 31. **b** Deficit. **c** Fiscal year ends Dec. 31. **d** Fiscal year ends May 31. **Note:** Fiscal years end March 31 for each year unless otherwise indicated. Fiscal year 1983 data are estimates. Results are converted from yen to U.S. dollars on the following basis: Fiscal year 1983: $1.00 = 236.7 Y; fiscal year 1982: $1.00 = 235.8 Y; fiscal year 1981: $1.00 = 222.4 Y; fiscal year 1980: $1.00 = 212.9 Y. Year-to-year changes in sales, net income, and assets are affected by fluctuations in the currency exchange rate. **Source:** Toyo Keizai Shinposha

6 Foreign Chemical Industries-Canada

Canadian chemical companies have recovered nicely from the sinkhole year of 1982, when sizable losses were the rule. Last year, higher sales turned 1982's red ink into black ink. Stronger demand, triggered by an improved economy at home and in the U.S., which is Canada's largest chemical export market, pushed up production of most chemicals and allowed higher plant operating rates.

But Canadian chemical companies aren't out of the woods yet. Case in point: The industry's chemical trade balance slipped back into deficit as imports surged while exports staged only a modest recovery. This indicates that Canadian chemical companies aren't so competitive as they would like to be. For this, they blame the country's energy policies, which have pushed petrochemical feedstock prices upward while they have been going down elsewhere. The industry is pressing for a new government pricing policy.

Chemical output up, but not to 1981 peak



a Gross domestic product. **Source:** Statistics Canada

COMPANY RESULTS: A return to profitability

$ Millions (Canadian)	Sales	Net income[a]	Profit margin	Capital expenditures	Employees (thousands)
C-I-L Inc.[b]					
1983	$1113.8	$23.9	2.1%	$109.0	6.7
1982	1059.8	15.2	1.4	85.5	6.9
1981	1149.9	54.3	4.7	94.1	7.8
1980	1004.2	51.5	5.1	70.2	8.3
Celanese Canada					
1983	$398.4	$ 9.0	2.3%	$12.3	3.4
1982	323.9	(5.6)[b]	—	59.8	3.4
1981	373.0	20.4	5.4%	87.7	3.5
1980	336.2	24.2	7.2	55.1	4.2
Du Pont Canada					
1983	$1116.0	$35.0	3.1%	$25.2	5.0
1982	980.0	(7.4)[b]	—	24.0	5.4
1981	1139.1	33.5	2.9%	47.0	6.1
1980	995.3	42.6	4.3	53.2	5.9
Polysar					
1983	$1336.9	$ 8.7	0.7%	$144.2	6.0
1982	1330.0	(30.5)[b]	—	207.0	6.6
1981	1049.0	74.0	7.1%	58.3	5.4
1980	1171.0	73.4	6.3	86.2	6.1
Union Carbide Canada					
1983	$687.0	($1.4)[b]	—	$ 55.9	4.2
1982	691.3	(17.9)[b]	—	67.6[c]	4.5
1981	827.3	36.1	4.4%	100.0	5.0
1980	794.8	79.6	10.0	58.9	5.0

a Excluding extraordinary gains and losses. **b** Deficit. **c** Excludes $50.9 million spent on Prentiss, Alta., ethylene glycol plant that was transferred to another Union Carbide subsidiary.

PRODUCTION: Several chemicals rebound

Thousands of metric tons	1983	1982	1981	Change 1982-83
ORGANIC CHEMICALS				
Benzene	580	519	571	12%
Butadiene	133	118	126	13
Butylene	138	107	124	29
Ethylene	1196	1013	1330	18
Formaldehyde	90	70	85	29
Methanol	1670	na	na	—
Propanol	63	67	73	−6
Propylene	715	693	671	3
Toluene	411	471	480	−13
Urea	1445	1231	1303	17
Xylene	432	431	409	0
INORGANIC CHEMICALS				
Ammonia, anhydrous 100%	2888	2509	2654	15
Ammonium nitrate	934	1018	1212	−8
Ammonium phosphate	1259	1027	1355	23
Chlorine	1385	1233	1292	12
Hydrochloric acid	170	143	186	19
Nitric acid	855	977	1158	−12
Phosphoric acid, 100% P_2O_5	656	553	744	19
Sodium chlorate	294	264	255	11
Sodium hydroxide	1528	1367	1458	12
Sulfuric acid	3686	3131	4117	18
SYNTHETIC RESINS				
Polyesters, unsaturated	26	27	28	−4
Polyethylene, high density	211	194	222	9
Polyethylene, low density	412	376	410	10
Polyvinyl chloride	243	193	222	26

na = not available. **Source:** Statistics Canada

SHIPMENTS: Strong upsurge for plastics, drugs, fibers, and paint

$ Millions (Canadian)	1983	1982	1981	1980	Change 1982-83
All manufacturing	$199,991	$183,803	$191,114	$168,365	9%
Chemicals and chemical products	14,446	12,885	13,190	11,218	12
Industrial chemicals, inorganic	2,373	2,287	2,191	1,856	4
Industrial chemicals, organic	3,184	2,804	3,212	2,643	14
Plastics and synthetic resins	1,517	1,298	1,512	1,372	17
Pharmaceuticals and medicinals	1,816	1,572	1,327	1,144	16
Fertilizers, mixed	218	200	211	189	9
Paint and varnish	1,001	835	880	747	20
Soap and cleaning compounds	1,176	1,049	1,020	866	12
Toilet preparations	692	607	588	504	14
Pigments and dry colors	289	258	250	221	12
Printing ink	205	193	189	169	6
Miscellaneous chemical products	1,974	1,782	1,810	1,508	11
Man-made fibers	1,380	1,141	1,404	1,270	21

Source: Statistics Canada

CHEMICAL IMPORTS: Sharp growth last year

$ Millions (Canadian)[a]	1983	1982	1981	Change 1982-83
Inorganic chemicals	$ 411	$ 370	$ 399	11%
Organic chemicals	1265	1019	1090	24
Fertilizers and fertilizer materials	185	143	157	29
Synthetic and reclaimed rubber	161	142	160	13
Plastics materials	751	549	607	37
Plastic film and sheet	268	208	243	29
Other plastic shapes and forms	182	137	154	33
Dyes, except dyeing intermediates	77	63	76	22
Pigments, lakes, and toners	81	52	65	56
Paints and related products	111	85	98	31
Other chemical products	903	817	765	11
TOTAL	**$4393**	**$3584**	**$3814**	23%
Imports from U.S.	**$3425**	**$2796**	**$3011**	22%
U.S. share, %	65%	63%	61%	—

Source: Statistics Canada

CHEMICAL EXPORTS: Modest recovery

$ Millions (Canadian)[a]	1983	1982	1981	Change 1982-83
Chemical elements	$ 187	$ 170	$ 147	10%
Other inorganic chemicals	784	827	1064	−5
Organic chemicals	1201	1099	1183	9
Fertilizers and fertilizer materials	1168	1059	1343	10
Synthetic rubber and plastic materials	521	516	513	1
Plastics, basic shapes and forms	198	173	149	14
Other chemical products	284	229	206	24
TOTAL	**$4345**	**$4073**	**$4605**	7%
Exports to U.S.	**$2843**	**$2528**	**$2826**	12%
U.S. share, %	65%	63%	61%	—

a Domestic exports only. **Source:** Statistics Canada

TRADE BALANCE: Total surplus narrows

$ Millions (Canadian)	1983	1982	1981	1980
Total exports	$88,426	$81,829	$81,337	$74,446
Total imports	75,694	67,926	79,482	69,274
Trade balance	12,732	13,903	1,855	5,172

Import surge wipes out chemical trade surplus

Chemical exports	$ 4,345	$ 4,073	$ 4,605	$ 4,056
Chemical imports	4,393	3,584	3,814	3,354
Chemical trade balance	−48	489	791	702

Source: Statistics Canada

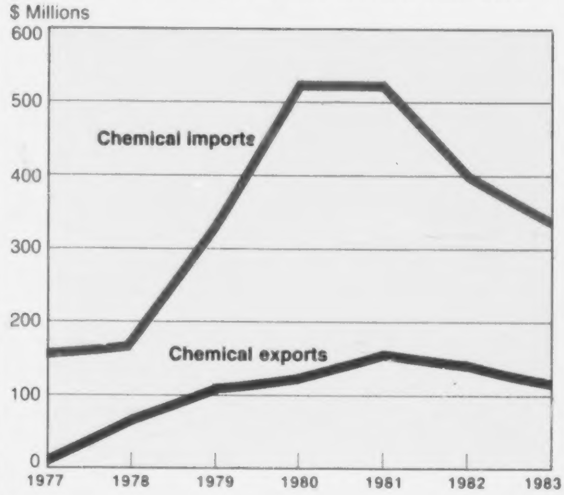
PRICES: Chemicals show a moderate rise

Industry selling price indexes, 1971 = 100	Annual average 1983	1982	1981	Change 1982-83
All manufacturing	298.7	288.8	272.4	3%
Chemicals and chemical products	316.6	306.9	286.4	3
Industrial chemicals—inorganic	341.4	337.5	313.9	1
Ammonium nitrate[a]	208.9	221.5	212.2	−6
Chlorine	360.2	315.5	275.2	14
Oxygen	237.7	224.0	215.5	6
Sodium hydroxide	467.1	450.1	383.8	4
Industrial chemicals—organic	439.2	429.7	410.3	2
Plastics and synthetic resins	314.3	297.7	294.6	6
Alkyds	211.7	209.0	196.5	1
Phenol-formaldehyde	354.0	344.5	337.4	3
Polyethylene	309.9	290.2	326.9	7
Fertilizers, mixed	284.2	294.5	289.5	−3
Pharmaceuticals and medicinals	233.6	211.9	189.8	10
Paint and varnish	304.3	300.0	283.0	1
Pesticides	332.7	316.6	287.3	5
Synthetic fibers	242.7	254.9	251.9	−5
Petroleum refineries	685.2	643.7	559.8	6
Benzene	446.3	427.4	488.4	4
Toluene	606.0	620.4	592.4	−2
Xylene	544.6	558.0	521.3	−2

a Fertilizer grade. **Source:** Statistics Canada

6 Foreign Chemical Industries–Mexico

Exports decline but trade deficit narrows



Note: Trade in primary petrochemicals only, does not include secondary chemicals
Source: Petroleos Mexicanos

CHEMICAL IMPORTS: Local output cuts some

Thousands of metric tons[a]	1983	1982	1981	1980	Change 1982–83
Acetaldehyde	42.3	12.9	5.9	58.2	228%
Acrylonitrile	28.5	16.8	19.7	8.6	70
Benzene	0.0	12.2	21.0	14.5	—
Butadiene	45.0	49.6	55.0	54.8	−9
Cyclohexane	2.6	13.0	7.9	10.1	−80
Dichloroethane	24.7	0.0	1.7	14.3	—
Dodecylbenzene	51.3	47.4	32.8	41.3	8
Ethylbenzene	5.8	15.9	10.8	10.0	−64
Ethylene	0.0	31.4	15.1	0.0	—
Ethylene oxide	0.0	0.0	31.1	34.4	—
Isopropyl alcohol	24.9	31.1	15.1	18.0	−20
Perchloroethylene	9.0	11.6	16.7	5.5	−22
Polyethylene, high density	49.2	17.1	10.2	26.0	24
Polyethylene, low density	88.0	105.7	125.9	104.0	−17
Propylene	17.1	22.1	24.3	20.3	−23
Propylene tetramer	5.8	15.2	23.1	14.5	−62
Styrene	65.6	60.9	87.8	76.7	8
Toluene	0.0	11.8	22.8	36.7	—
***o*-Xylene**	6.8	9.8	12.1	13.3	−31
***p*-Xylene**	24.5	130.6	148.0	94.5	−81

a Imports by Petróleos Mexicanos (Pemex) of primary petrochemicals. **Source:** Pemex

DOMESTIC SALES: Some big increases

Thousands of metric tons[a]	1983	1982	1981	1980	Change 1982–83
Acetaldehyde	199.9	156.2	123.7	100.9	28%
Acrylonitrile	85.9	71.4	74.2	67.9	20
Ammonia, anhydrous	1454.9	1338.1	1204.8	966.8	9
Benzene	11.0	12.8	12.2	12.6	−14
Butadiene	84.1	65.9	69.5	66.1	28
Cyclohexane	51.3	50.5	52.6	52.8	2
Dodecylbenzene	106.9	111.3	92.5	90.1	−4
Ethylene oxide	105.4	77.6	77.9	70.5	36
Hexane	47.0	54.2	51.0	46.1	−13
Isopropyl alcohol	53.6	47.4	32.4	27.8	13
Methanol	139.8	129.0	125.2	97.8	8
Polyethylene, high density	120.3	120.3	100.1	79.5	0
Polyethylene, low density	250.9	261.3	257.5	224.3	−4
Styrene	116.3	117.6	116.9	101.2	−1
Sulfur	319.2	365.2	427.5	408.0	−13
Toluene	81.1	86.5	88.4	81.3	−6
Vinyl chloride	205.6	138.7	144.7	148.1	48
***o*-Xylene**	33.3	26.9	27.0	30.7	24
***p*-Xylene**	131.3	186.9	186.8	116.4	−30

a Domestic sales by Petroleos Mexicanos (Pemex) of primary petrochemicals. **Source:** Pemex

PRODUCTION: New capacity spurs gains

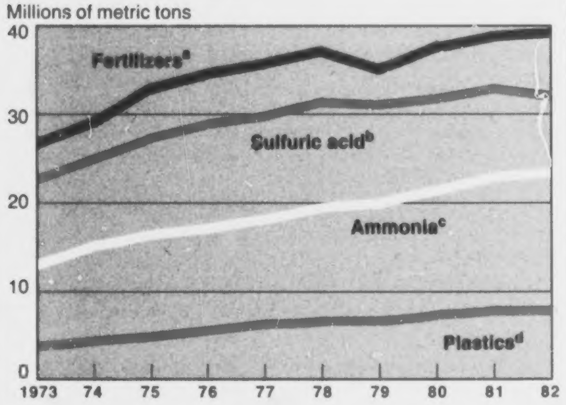
Thousands of metric tons[a]	1983	1982	1981	1980	Change 1982–83
Acetaldehyde	152.9	149.1	122.2	47.6	3%
Acrylonitrile	55.3	52.7	54.0	54.3	5
Ammonia, anhydrous	2354.6	2469.3	2183.2	1883.2	−5
Benzene	138.8	96.0	76.5	79.3	45
Butadiene	18.5	14.6	12.3	17.0	27
Cyclohexane	48.5	34.9	44.1	39.7	40
Cumene	36.6	20.4	1.6	0.0	79
Dichloroethane	265.2	201.1	116.9	106.3	32
Dodecylbenzene	56.6	61.8	59.5	55.4	−8
Ethane	1637.9	1550.3	1337.4	632.2	6
Ethylbenzene	24.2	23.0	29.1	29.3	5
Ethylene	645.1	395.8	378.3	365.5	63
Ethylene oxide	112.0	79.0	48.5	29.7	42
Hexane	64.4	75.8	65.6	60.1	−15
Hydrochloric acid	78.9	46.7	33.2	36.1	69
Isopropyl alcohol	11.9	10.9	15.6	12.6	9
Methanol	205.6	191.3	179.7	173.6	7
Nitrogen	45.0	39.0	29.5	0.0	15
Oxygen	213.6	208.4	159.1	0.0	2
Polyethylene, high density	82.2	78.2	78.1	66.9	5
Polyethylene, low density	88.3	93.3	91.2	91.4	−5
Propylene	190.7	157.6	156.2	136.9	21
Propylene tetramer	29.6	38.5	35.4	35.8	−23
Styrene	24.0	29.0	32.9	31.3	−17
Sulfur, recovered	377.2	424.9	425.5	402.4	−11
Toluene	222.6	138.1	131.6	124.9	61
Vinyl chloride	134.4	79.4	56.9	62.5	69
***m*- and *p*-Xylene**	197.2	99.2	86.6	77.2	99
***o*-Xylene**	38.6	15.8	16.7	16.1	144

a Production of primary petrochemicals by Petróleos Mexicanos (Pemex). **Source:** Pemex

The centrally planned economies of East Europe and the Soviet Union turned upwards in 1983, reversing the decelerating trend in industrial growth that started in the late 1970s. Industrial output for the region rose 4.2%, surpassing the goal of 3.4%. This almost doubled the slow growth rates of 1982 (2.4%) and 1981 (2.2%), which had fallen far short of five-year-plan targets (4.2% and 4.0%, respectively). Growth was spurred particularly by recovery in Poland (output up 6.7%).

Most nations of the region stepped up chemical production as well, with several registering higher growth rates for output of chemicals and rubber than for industry as a whole. Bulgaria led, with chemicals up 7.4% versus 4.6% for all industry. In the U.S.S.R., chemical output was up 6% compared to 4% for all industry, and in Romania it was up 5.8% versus 4.8% for all industry. Among key chemicals, the Soviets raised production of mineral fertilizers 11.1%, plastics 8.5%, and pesticides 4.5%.

Growth slows for several important chemical products



a As N, P_2O_5, and K_2O. b 100% H_2SO_4. c Nitrogen content. d Including resins for man-made fibers in U.S.S.R. **Note:** Data for U.S.S.R., Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania.
Sources: Central Intelligence Agency, Department of Agriculture, C&EN estimates

MAN-MADE FIBERS: U.S.S.R. makes more than half produced in eastern bloc

Production, thousands of metric tons	1983	1982	1981	1980	Change 1982-83
Bulgaria	101	105	101	96	−4%
Czechoslovakia	186	180	169	165	3
East Germany	na	301	303	293	—
Hungary	27	28	29	29	−4
Poland	232	201	205	256	15
Romania	171	156	145	152	10
U.S.S.R.	1400	1235	1213	1176	13
TOTAL	**na**	**2206**	**2165**	**2167**	—

na = not available. **Source:** United Nations Economic Commission for Europe

PRODUCTION GROWTH: 1983 brings pickup

% annual change in gross output	1983	1982	1981	1980	1979
U.S.S.R. and East Europe					
All industry	4.2%	2.4%	2.2%	3.4%	3.7%
Bulgaria					
All industry	4.6	4.6	4.8	4.2	5.5
Chemicals and rubber	7.4	6.4	4.2	11.1	9.1
Czechoslovakia					
All industry	2.7	1.1	2.1	3.5	3.7
Chemicals and rubber	2.7	1.4	1.7	4.8	3.3
East Germany					
All industry[a]	4.1	3.2	4.7	4.7	4.6
Chemicals and rubber	na	4.0	3.7	3.3	4.0
Hungary					
All industry	1.0	2.5	2.8	−2.0	3.0
Chemicals and rubber	1.6[b]	1.9	3.1	−2.1	6.1
Poland					
All industry	6.7	−2.1	−10.8	0.0	2.7
Chemicals and rubber	na	0.1	−11.4	0.4	2.3
Romania					
All industry	4.8	1.1	2.6	6.5	8.1
Chemicals and rubber	5.8	1.4	3.9	6.8	1.4
U.S.S.R.					
All industry[c]	4.0	2.9	3.4	3.6	3.4
Chemicals and rubber[c]	6.0	3.0	5.9	5.6	2.3
All industry[d]	na	2.2[e]	2.5	2.8	2.1
Chemicals and rubber[d]	na	1.6[e]	4.0	4.7	−0.2

a Industrial commodity production. b For socialist industry only. c Figures based on official Soviet statistics. d Figures based on Central Intelligence Agency estimates, giving lower results because of postulated upward bias in official figures. e Preliminary figure. **na** = not available.
Sources: United Nations Economic Commission for Europe, based on official national statistics, Central Intelligence Agency

AGRICULTURAL CHEMICALS: Little growth in fertilizer supply except in Soviet Union

Thousands of metric tons	1983[a]	1982	1981	1980	1979
Bulgaria					
Fertilizer supply[b]	1,031	1,038	1,044	830	820
Pesticide supply[c]	na	40.4	48.7	40.0	34.8
Czechoslovakia					
Fertilizer supply[b]	na	1,741	1,720	1,730	1,745
East Germany					
Fertilizer supply[b]	1,385	1,408	1,726	1,637	1,713
Pesticide supply[c]	na	26.7	27.0	27.0	26.7
Hungary					
Fertilizer supply[b]	1,530	1,528	1,485	1,399	1,502
Poland					
Fertilizer supply[b]	na	3,346	3,499	3,635	3,567
Pesticide supply[d]	47.3	52.4	38.4	29.3	44.4
Romania					
Fertilizer supply[b]	na	1,114	1,618	1,185	1,431
U.S.S.R.					
Fertilizer supply[b]	23,000	20,152	19,176	18,763	17,335
Pesticide supply[d]	557	533	504	471	475

a Preliminary figures. b Nutrient content. c On basis of active substance. d On conventional weight basis. **na** = not available. **Sources:** United Nations Economic Commission for Europe, based on official national statistics; Department of Agriculture

PRODUCTION: Soviet Union posted stronger growth last year than in 1982

Thousands of metric tons, unless otherwise noted	1983[a]	1982	1981	1980	1979
U.S.S.R.					
Sulfuric acid, 100%	24,700	23,800	24,095	23,033	22,364
Mineral fertilizers[b]	29,700	~~26,738~~	25.998	24,767	22,137
Nitrogen[b]	13,095	11,593	10,705	10,241	9,151
Phosphate[b,c]	7,315	7,057	6,836	6,455	6,344
Potassium[b]	9,280	8,079	8,449	8,064	6,635
Synthetic ammonia[d]	na	15,400	14,718	13,762	12,278
Plastics[e]	4,400	4,057	4,089	3,637	3,478
Sodium hydroxide, 100%	2,900	2,783	2,757	2,755	2,680
Synthetic rubber[f]	na	1,815	1,860	1,880	1,867
Rubber tires[g] (thousands of units)	62,000	61,700	60,500	60,100	59,981
Pesticides	557	533	504	470	475
BULGARIA					
Sulfuric acid, 100%	na	892	920	852	998
Mineral fertilizers[b]	na	999	1,011	947	959
Nitrogen[b]	na	760	753	730	677
Phosphate[b]	na	239	258	217	282
Synthetic ammonia[d]	na	na	1,023	1,009	951
Plastics	na	325	290	255	200
Sodium hydroxide, 100%	na	155	151	162	107
Synthetic rubber	na	30	30	30	30
Rubber tires[g] (thousands of units)	na	na	2,230	2,117	1,793
CZECHOSLOVAKIA					
Sulfuric acid, 100%	na	1,252	1,318	1,284	1,253
Mineral fertilizers[b]	na	na	1,085	1,182	1,147
Nitrogen[b]	na	567	539	618	591
Phosphate[b,c]	na	335	340	361	357
Potassium[b,h]	na	na	206	203	199
Synthetic ammonia[d]	na	na	na	841	804
Plastics	1,006	956	913	894	853
Sodium hydroxide, 100%	na	315	330	325	312
Synthetic rubber	na	65	63	60	59
Rubber tires[g] (thousands of units)	na	na	6,844	6,740	6,581
EAST GERMANY					
Sulfuric acid, 100%	na	920	948	958	952
Mineral fertilizers[b]	na	4,668	4,787	4,735	4,681
Nitrogen[b]	na	948	967	943	875
Phosphate[b,c]	na	286	360	370	411
Potassium[b]	na	3,434	3,460	3,422	3,395
Synthetic ammonia[d]	na	na	1,403	1,159	1,079
Plastics	na	990	998	861	779
Sodium hydroxide, 100%	na	695	631	626	548
Synthetic rubber	na	155	155	150	150
Rubber tires[g] (thousands of units)	na	7,056	7,026	7,067	6,890
HUNGARY					
Sulfuric acid, 100%	na	600	546	608	603
Mineral fertilizers[b]	na	na	899	847	858
Nitrogen[b]	na	571	589	559	550
Phosphate[b]	na	155	158	149	165
Potassium[b,h]	na	na	152	139	143
Synthetic ammonia[d]	na	na	819	795	803
Plastics	345	326	314	328	294
Sodium hydroxide, 100%[i]	na	178	180	188	194
Rubber tires[g] (thousands of units)	na	na	838	840	750
POLAND					
Sulfuric acid, 100%	na	2,682	2,776	3,019	2,983
Mineral fertilizers[b]	2,324	2,283	2,242	2,238	2,431
Nitrogen[b]	na	1,297	1,274	1,290	1,376
Phosphate[b]	na	868	866	843	931
Potassium[b,h]	na	118	102	105	124
Synthetic ammonia[d]	na	na	1,465	1,483	1,530
Plastics	na	438	476	549	440
Sodium hydroxide, 100%	na	363	400	415	436
Synthetic rubber	na	100	111	118	130
Rubber tires[g] (thousands of units)	na	5,693	na	8,743	8,500
ROMANIA					
Sulfuric acid, 100%	na	1,600	1,814	1,756	1,750
Mineral fertilizers[b]	2,880	2,692	2,641	2,451	2,522
Nitrogen[b]	na	2,008	1,822	1,707	1,738
Phosphate[b]	na	na	717	687	709
Potassium[b,h]	na	na	102	57	75
Synthetic ammonia[d]	na	na	2,383	2,247	2,333
Plastics	na	591	584	579	516
Sodium hydroxide, 100%	na	na	767	723	704
Synthetic rubber	na	160	146	150	149
Rubber tires[g] (thousands of units)	na	na	5,170	5,046	4,691

a Approximate figures. **b** Nutrient content basis, as N, P_2O_5, or K_2O. **c** Including production of ground phosphate rock for direct applications and phosphate animal feeds. **d** Nitrogen content. **e** Including resins for man-made fibers. **f** Estimated. **g** For all motor vehicle tires, excluding aircraft and bicycle tires. **h** Imported potash added to domestically produced nitrogen and phosphate to form multinutrient fertilizer. **i** Including regenerated NaOH. **na** = not available. **Sources:** Central Intelligence Agency, Department of Commerce, Department of Agriculture, United Nations Economic Commission for Europe (based on official national statistics)

SOVIET FOREIGN TRADE: Overall trade balance continues to widen

$ Millions	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
Exports[a]	$93,685	$87,170	$79,377	$76,437	$64,912	$52,435	$45,227	$37,269	$33,407	$27,374	$21,332
Imports[a]	82,227	77,848	73,158	68,473	57,958	50,798	40,926	38,212	37,070	24,861	20,980
Trade balance	11,458	9,322	6,219	7,964	6,954	1,637	4,301	−943	−3,663	2,513	352
Chemical exports[a]	na	na	2,380	2,139	1,606	1,284	1,063	939	1,027	887	549
Chemical imports[a]	na	na	4,031	3,732	2,803	2,188	1,850	1,668	1,747	1,448	954
Chemical trade balance	na	na	−1,651	−1,593	−1,197	−904	−787	−729	−720	−561	−405

a Free on board. **na** = not available. **Sources:** Central Intelligence Agency, Department of Commerce, based on official Soviet statistics and exchange rates

KOREA

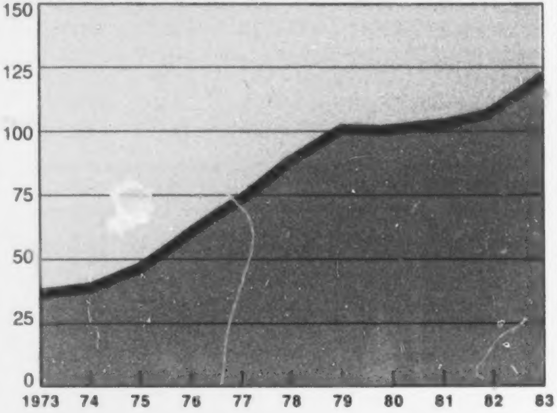
INDUSTRY TRENDS: Output up sharply

Index, 1980 = 100	1983	1982	1981	1980	Change 1982-83
Chemicals, petroleum, coal, rubber, and plastic products					
Production	123.4	105.9	102.5	100.0	17%
Shipments	119.3	102.1	101.6	100.0	17
Inventories	121.1	118.1	115.0	100.0	3
Industrial chemicals					
Production	116.0	101.8	103.7	100.0	14
Shipments	125.1	108.2	105.4	100.0	16
Inventories	114.9	121.1	126.9	100.0	−5
Other chemical products					
Production	143.5	122.4	106.1	100.0	17
Shipments	141.2	119.3	106.7	100.0	18
Inventories	142.5	118.5	94.7	100.0	20
Rubber products					
Production	113.4	98.1	99.4	100.0	16
Shipments	112.0	93.7	95.3	100.0	20
Inventories	107.4	98.2	109.8	100.0	9
Plastic products					
Production	124.2	92.9	91.8	100.0	34
Shipments	123.6	92.6	91.3	100.0	33
Inventories	132.0	121.9	96.5	100.0	8
All manufacturing					
Production	137.6	118.7	113.4	100.0	16
Shipments	134.8	115.5	111.3	100.0	17
Inventories	125.9	126.1	110.1	100.0	0

Source: Korean Bureau of Statistics

Output of chemicals spurts after slow growth during early 1980s

Index, chemicals and related products,[a] 1980 = 100



a Includes petroleum, coal, rubber, and plastic products.
Source: Korean Bureau of Statistics

FOREIGN TRADE: Chemical deficit widens

$ Millions	1983	1982	1981	1980
Exports[a]	$24,445	$21,853	$21,254	$17,505
Imports[b]	26,192	24,251	26,131	22,292
Trade balance	−1,747	−2,398	−4,877	−4,787
Chemical exports	738	740	682	780
Chemical imports	2,281	2,084	2,109	1,836
Chemical trade balance	1,543	−1,344	−1,427	−1,055

a Free on board. b Includes cost, insurance, freight. **Source:** Korean Bureau of Statistics

PRODUCTION: Fertilizers falter

Thousands of metric tons	1983	1982	1981	1980	Change 1982-1983
Sulfuric acid	1610	1596	1304	1702	1%
Complex fertilizers	1614	1667	1211	1439	−3
Ammonia	523	661	908	1031	−21
Urea fertilizers	737	788	1070	973	−6
Ethylene	491	374	374	368	31
Polyethylene	279	218	200	228	28
Polyester fibers	217	189	193	161	15
Insecticides	87	58	54	75	50
Synthetic detergents	57	52	57	64	10

Source: Korean Bureau of Statistics

AUSTRALIA

PRODUCTION: Mostly lower last year

Thousands of metric tons	1983[a]	1982[a]	1981[a]	1980[a]	Change 1982-83
Chemicals and acids					
Hydrochloric acid, 100%	60	55	59	63	10%
Nitric acid, 100%	189	180	182	180	5
Sulfuric acid, 100%	1782	2027	1963	2175	−12
Ammonium sulfate	200	207	211	203	−3
Superphosphate[b]	2986	3568	3770	4202	−16
Plastics and resins	776	800	789	783	−3
Synthetic detergents	209	211	200	202	−1
Unsupported plastics film, sheeting	112	119	125	130	−5
Polyethylene[c]	80	82	84	89	−2
Polyvinyl chloride[d]	17	18	18	17	−9

a Years ending June 30. b Includes double and triple superphosphates and ammonium phosphate expressed in terms of single phosphate (22% P_2O_5 equivalent). c Low and high density. d Including copolymers. **Source:** Australian Bureau of Statistics

FOREIGN TRADE: Import drop brings surplus

$ Millions	1983[a]	1982[a]	1981[a]	1980[a]
Exports[b,c]	$20,733	$20,939	$22,314	$21,079
Imports[d]	20,515	24,608	22,068	18,116
Trade balance	218	−3,669	246	2,963
Chemical exports[b,c]	438	430	487	424
Medicinal products	109	95	95	78
Chemical imports[d]	1,668	1,955	1,842	1,764
Organic chemicals	439	530	509	543
Chemical trade balance	−1,230	−1,525	−1,355	−1,340

a Years ending June 30. b Free on board. c Includes re-exports. d Values for customs purposes, free-on-board basis. **Source:** Australian Bureau of Statistics

CHINA

PRODUCTION: Chemicals generally continue to score solid growth

Thousands of metric tons	1983	1982	1981	1980	Change 1982-83
Ammonia[a]	na	12,430	11,990	12,150	na
Fertilizer[b]	13,798	12,781	12,390	12,320	8%
Nitrogen (N)	11,094	10,219	9,860	9,990	9
Phosphate (P_2O_5)[c]	2,666	2,537	2,510	2,310	5
Potash (K_2O)	29	25	20	20	16
Sulfuric acid	8,700	8,170	7,810	7,640	6
Sodium hydroxide	2,123	2,073	1,923	1,923	2
Sodium carbonate	1,793	1,735	1,652	1,613	3

Thousands of metric tons	1983	1982	1981	1980	Change 1982-83
Calcium carbide	na	1670	1510	1520	10%
Plastics	1121	1003	916	898	12
Insecticides	331	457	484	537	−28
Ethylene	650	560	500	490	16
Synthetic detergents	677	569	478	393	19
Man-made fibers	541	517	527	450	5
Pharmaceuticals	48	42	37	40	14

a Nitrogen content of ammonia produced for fertilizer. b Nutrient content. c Including production of ground phosphate rock for direct application and phosphate animal feeds. na = not available.
Sources: State Statistical Bureau of the People's Republic of China, Central Intelligence Agency

CHEMICAL IMPORTS: Fertilizers drop further

$ Millions[a]	1982	1981	1980	Change 1981-82
Fertilizers[b]	$ 534	$ 798	$ 969	−33%
Nitrogenous fertilizer	na	500	674	na
Chemical elements and compounds	456	476	536	−4
Organic chemicals	na	381	391	na
Plastic materials, resins	590	474	369	25
Dyeing, tanning, and coloring materials	125	109	79	15
Medicinal products	30	28	19	10
Essential oils, perfume, and cleansing materials	21	16	9	30
Other chemicals[c]	183	153	180	19
TOTAL	**$1940**	**$2054**	**$2162**	−6%

a Free on board. b Manufactured. c Includes explosives and pyrotechnic products; mineral tar and crude chemicals from coal, oil, and natural gas; and chemical materials and products not elsewhere specified. na = not available. **Source:** Central Intelligence Agency, estimated from data reported by China's trade partners

CHEMICAL EXPORTS: Moderately higher

$ Millions[a]	1982	1981	1980	Change 1981-82
Chemical elements and compounds	$ 595	$ 551	$ 478	8%
Organic chemicals	na	297	275	na
Medicinal products	204	190	184	7
Essential oils, perfume, and cleansing materials	107	89	98	20
Explosives and pyrotechnic products	112	93	94	20
Plastic materials, resins	46	61	73	−25
Dyeing, tanning, and coloring materials	72	62	58	17
Mineral tar and crude chemicals[b]	27	56	27	−51
Fertilizers[c]	6	5	4	11
Other chemical products	164	188	165	−13
TOTAL	**$1332**	**$1296**	**$1181**	3%

a Free on board. b From coal, oil, and natural gas. c Manufactured. na = not available. **Source:** Central Intelligence Agency, estimated from data reported by China's trade partners

TAIWAN

INDUSTRY TRENDS: Petrochemicals set pace

Industrial production indexes, 1981 = 100	1983	1982	1981	1980	Change 1982-83
All manufacturing	115.2	100.5	100.0	96.1	15%
Chemical materials	115.9	100.6	100.0	96.1	15
Basic chemicals	108.0	100.5	100.0	98.9	7
Petrochemicals	113.4	95.7	100.0	95.8	18
Fertilizers	74.0	72.8	100.0	106.1	2
Synthetic fibers	119.9	104.1	100.0	92.6	15
Plastics and resins	125.5	107.9	100.0	99.1	16
Chemical products	122.2	118.3	100.0	90.2	3

Source: Taiwan Ministry of Economic Affairs

FOREIGN TRADE: Chemical deficit expands

$ Millions	1983	1982	1981	1980
Exports[a]	$25,123	$22,204	$22,611	$19,811
Imports[b]	20,287	18,888	21,200	19,733
Trade balance	4,836	3,316	1,411	78
Chemical exports[a]	1,041	1,012	973	492
Chemical imports[b]	2,814	2,312	2,705	2,023
Chemical trade balance	−1,773	−1,299	−1,731	−1,530

a Free on board. b Includes cost, insurance, and freight. **Sources:** Taiwan Council for Economic Planning & Development, C&EN estimates

PRODUCTION: Major inorganics remain depressed

Thousands of metric tons, unless otherwise noted	1983	1982	1981	1980	Change 1982-83
Man-made fibers	840	730	687	633	15%
Sulfuric acid	678	685	819	769	−1
Polyvinyl chloride	522	459	456	454	14
Ethylene	499	452	443	458	10
Vinyl chloride	458	434	411	405	6
Ammonium sulfate	381	373	504	539	2
Ammonia, anhydrous	378	386	494	504	−2
Sodium hydroxide	295	359	373	411	−18
Xylene[a]	275	230	277	311	20
Compound fertilizer	275	247	330	343	11
Propylene	250	225	204	213	11
Hydrochloric acid	212	191	184	179	11
Benzene[a]	182	130	137	145	41
Urea	171	175	285	343	−3
Calcium superphosphate	159	160	226	207	−1
Ethylene glycol	151	120	156	133	26
Oxygen[b]	125	156	174	159	−20
Toluene[a]	115	113	172	153	2
Paints	108	97	84	79	10

a Millions of liters. b Millions of cubic meters. **Source:** Taiwan Ministry of Economic Affairs

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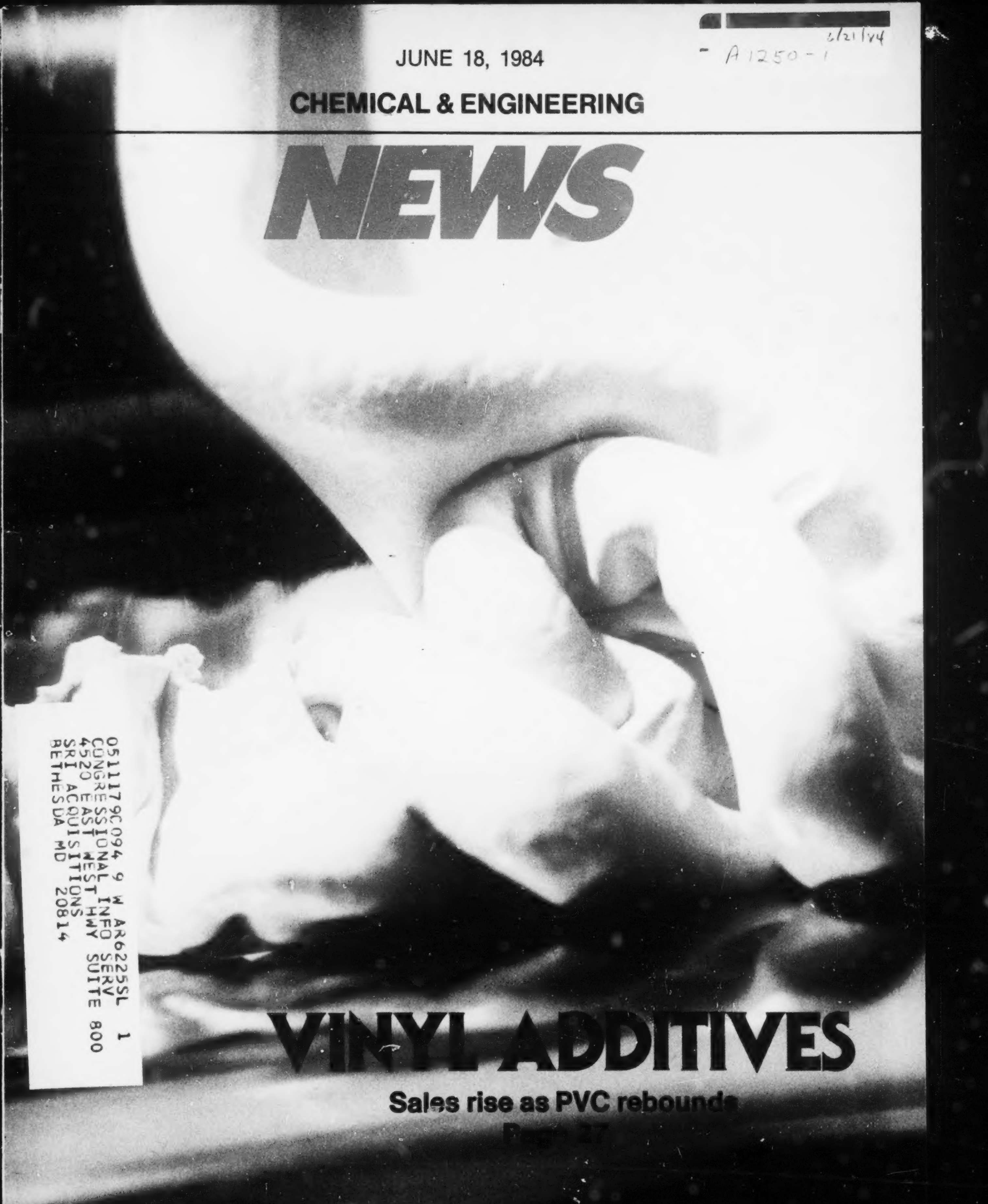
JUNE 18, 1984

CHEMICAL & ENGINEERING NEWS



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VINYL ADDITIVES

Sales rise as PVC rebounds

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CHEMICAL & ENGINEERING
NEWS

JUNE 18, 1984

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- **GAO assessment of studies of research instrument needs of U.S. universities finds no clear picture of current wants.** **Page 6**
- **Initial tests begin of DOE's Gas Centrifuge Enrichment Plant in Piketon, Ohio.** **Page 7**
- **Four cancer researchers receive GM foundation awards.** **Page 7**
- **Study finds a one-to-one relationship between SO_2 emissions and wet deposition of sulfate in eastern North America.** **Page 8**
- **W. R. Grace and Cetus form partnership to develop biotechnology-based agricultural products.** **Page 8**
- **Premier polymer research center is aim of incorporation of public foundation into Central Michigan University.** **Page 8**

Cover: Photo courtesy of Argus Chemical division, Witco Chemical

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Business

Biotechnology firms beef up their administrative, manufacturing staffs as emphasis shifts from lab to market. **Page 10**

Government

House votes on budgets of most major research-funding agencies, adding to or taking away from requests at its discretion. **Page 17**

Science

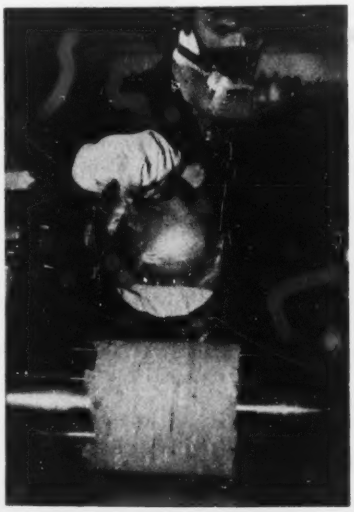
Lack of data on health effects of hazardous wastes concerns health, industry, environmental groups at symposium. **Page 21**

Bridged di-iron complexes that model active site of important biological molecules prepared and characterized. **Page 23**

Methylenecyclopropene synthesized independently by chemists at Rice University and University of Nebraska, Lincoln. **Page 26**

ACS News

Suggested topics for university chemistry course planning made available by ACS Committee on Professional Training. **Page 55**



Plastics Additives Report

Additives are doing a good business, as sales for polyvinyl chloride increase and compounders use larger amounts of more additives. **Page 27**

House Acting Fast On Fiscal 1985 Money Bills

Well ahead of deadlines, the House has voted on budgets for all but two of the major research-funding agencies, rearranging some priorities

Janice R. Long, C&EN Washington

For the second year in a row the House is proving that when it wants to it can move very fast indeed. Even before the June 15 deadline for reporting appropriation bills, setting actual funding levels, had arrived, the House had passed a number of fiscal 1985 money bills. In fact by June 7 only the budgets for two of the major research funding agencies—the Department of Defense and the National Institutes of Health—had not been voted on.

As usual the House is setting its own budget priorities, adding some money here, taking some away there from the amounts requested by the Administration for the various agencies. Even when the totals come out to the original number, there's a better than even chance that some rearranging of budget priorities and funding has taken place. House Republicans, concerned that in many cases the totals are higher than what the Administration wanted to spend, have been offering floor amendments requiring across-the-board reductions in several appropriation bills.

The House passed its first fiscal 1985 appropriation bill, H.R. 5653, covering energy and water development in May. It contains almost $2 billion for the Department of Energy's energy supply R&D activities. (Fossil energy R&D is not included in that amount since its funding is set in the Interior appropriation bill.) That's a scant 1% less than DOE has available in this fiscal year and 2% less than the Administration requested. But the House did perform some major surgery on the budget request.

For instance, the Administration had requested a 3% increase in funding for magnetic fusion research; what the House approved was an 11% decrease to $419 million. In some areas, such as solar energy, electric energy systems, and storage and geothermal energy, the House approved a funding level higher than that requested by the Administration but still lower than this year's funding levels, repeat-

House pares most R&D agencies' budget requests

	1985			% change
$ Millions	Appropriation	Request	1984	1984–85
NASA	**$ 7,491.4**	**$ 7,491.4**	**$ 7,197.5**	**4.1%**
Space-flight control and data communication	3,602.8	3,600.3	3,791.6	−5.0
R&D	2,422.6	2,400.1	2,011.9	20.4
Research and program management	1,316.0	1,331.0	1,238.5	6.2
Facilities	150.0	160.0	155.5	−3.5
Energy	**3,762.2**	**3,974.0**	**3,479.7**	**8.1**
Energy supply R&D	**1,997.0**	**2,037.9**	**2,012.7**	**−0.8**
Nuclear	613.0	623.0	674.6	−9.1
Supporting research and technical analysis	493.8	479.6	395.1	25.0
Magnetic fusion	419.1	483.1	470.7	−11.0
Environment	226.2	226.2	216.0	4.7
Solar	174.5	163.6	181.6	−3.9
Electric energy systems and storage	40.3	35.3	44.2	−8.8
Geothermal	30.1	27.1	30.5	−1.3
Weapons R&D	**1,038.3**	**1,085.1**	**825.8**	**25.7**
General science and research	**726.9**	**851.0**	**641.2**	**13.4**
NSF	**1,499.8**	**1,501.8**	**1,320.3**	**13.6**
Research and related programs	1,293.2	1,308.2	1,140.3	13.4
Antarctic programs	115.1	115.1	102.1	12.7
Science education activities	88.7	75.7	75.0	18.3
Scientific activities overseas	2.8	2.8	2.9	−3.4
EPA	**1,301.3**	**1,198.7**	**1,111.5**	**17.1**
Salaries and expenses[a]	672.3	639.3	574.9	16.9
Abatement, control, and compliance	436.0	396.0	393.9	10.7
R&D	193.0	163.4	142.7	35.2
Commerce	**1,287.9**	**1,030.6**	**1,157.3**	**11.3**
NOAA	1,069.9	802.9	961.2	11.3
NBS	120.5	126.1	115.7	4.1
PTO	97.5	101.6	80.4	21.3
USDA	**745.8**	**761.5**	**733.8**	**1.6**
Agricultural Research Service	482.5	483.0	476.3	1.3
Cooperative State Research Service	251.8	266.8	247.6	1.7
National Agricultural Library	11.5	11.7	9.9	16.2
TOTAL	**$16,088.4**	**$15,958.1**	**$15,000.1**	**7.2%**

[a] Includes in-house research funding.

ing what has become a common pattern in recent years.

Conversely, the House added more money to the requested 21% increase for DOE's supporting research and technical analysis activities, which include chemical and materials research, to ensure the continuation of what have become controversial projects. The additions include $9.2 million for completion of the vitreous state laboratory at Columbia University; $3.0 million to continue the national center for chemical research at Catholic University; and $7 million for establishment of a supercomputer center at Florida State University. Funding for all other supporting research was set at the level requested by the Administration (C&EN, Feb. 13, page 6).

Next to come up for a floor vote was H.R. 5713, the Department of Housing & Urban Development-Independent Agencies appropriation bill. This bill, though it's hard to tell from the title, sets funding for the National Science Foundation, National Aeronautics & Space Administration, and Environmental Protection Agency.

The House-approved funding level for NSF is $1.5 billion, $2 million less than the budget request but $180 million more than is available this year. Funding for research and related activities is set at $1.3 billion, $15 million below the request but $153 million above this year's level. The House did a lot of rearranging within the research budget request, doubling the $20 million request for advanced scientific computing and the $2.5 million request for research improvement in minority institutions. It reinstated the experimental program to stimulate competitive research, funding it at a level of $1 million.

Inasmuch as the total provided for research activities is less than the amount requested by the Administration, something had to be cut to offset the above additions. That cut turned out to be $44 million from the budget requests for mathematical and physical sciences; engineering; astronomical, atmospheric, Earth, and ocean sciences; and program development and management areas to be allocated at NSF's discretion.

The bill also includes $88.7 million for the foundation's science education activities, $13 million more than was requested to hold spending essentially constant in fiscal 1985. The House additions are $8 million to increase both the number and annual stipend of graduate fellowship grants, which were already slated for an increase, and $5 million for instructional instrumentation for four-year colleges.

NASA's total budget, as approved by the House, is $7.5 billion, an increase of only 4% over fiscal 1984. However, the R&D budget would be up 20%, or $411 million, to $2.4 billion, $22.5 million more than requested. Included in the bill is the $150 million requested for development of a permanently manned space station.

The House added to the budget request $40 million for flight demonstration of the advanced communication technology satellite, $10 million each for physics and astronomy and planetary research and analysis; continued work on the advanced turboprop programs; and advanced work on a "shuttle derived" expendable launch vehicle. It subtracted $10 million from the aeronautics research and technology base request and told NASA to find some way to save another $37.5 million.

Under the bill, funding for EPA extramural R&D programs is set at $193 million, 18% higher than the request and 35% above fiscal 1984 funding levels. The $30 million addition to the budget request includes $5 million for health effects, exposure assessment, and biotechnology research; $5 million for exploratory research grants and centers; $4 million for hazardous waste control technology; $3.5 million for indoor air pollution research; and $1.5 million for acid rain research on atmospheric chemical transformation and transport processes.

These first appropriation bills passed with very little debate, but by the time the Commerce Department's appropriation bill, H.R. 5712, hit the floor the budget cutters were ready. They succeeded in getting an amendment approved that called for an across-the-board reduction of 4% for each line item of funding in the bill. That still left enough money for an increase of 11% in the National Oceanic & Atmospheric Administration budget, which the Administration wanted to cut 16%. Among the $312 million worth of additions to the budget request were $35 million for the Sea Grant program, $3.8 million for the Great Lakes environmental research laboratory, and $800,000 for acid rain research.

The reduction only made things worse, however, for the National Bureau of Standards. The Administration had asked for a 9% funding increase. The Appropriations Committee had approved a 10% increase. But the bill, as approved by the full House, allows only a 4% increase to $121 million. The bill does restore funding for the Center for Building Technology, the Institute for Computer Science & Technology, and the Center for Fire Research. However, funding for the Patent & Trademark Office would increase 21% to $97.5 million, buttressed by fees collected for processing patent and trademark applications.

The agriculture appropriation bill, H.R. 5743, also was the subject of an across-the-board cut, but of only 1%. The House set funding for the Agricultural Research Service at $483 million, $1 million over the request and $6 million over this year's level. It earmarked specific amounts for such things as feeds, hornfly, guar, bee, cherry dieback, and sugarcane research. It also endorsed spending $200,000 for a continued assessment of dioxin contamination in the Great Lakes food chain.

The House decreased the budget request for the Cooperative State Research Service by $15 million to $252 million. It reserved $17.1 million for special research grants in 40 research areas and in many cases stated where the money was to be spent. And, as usual, it cut the budget request for competitive research grants by $17 million to $32.2 million.

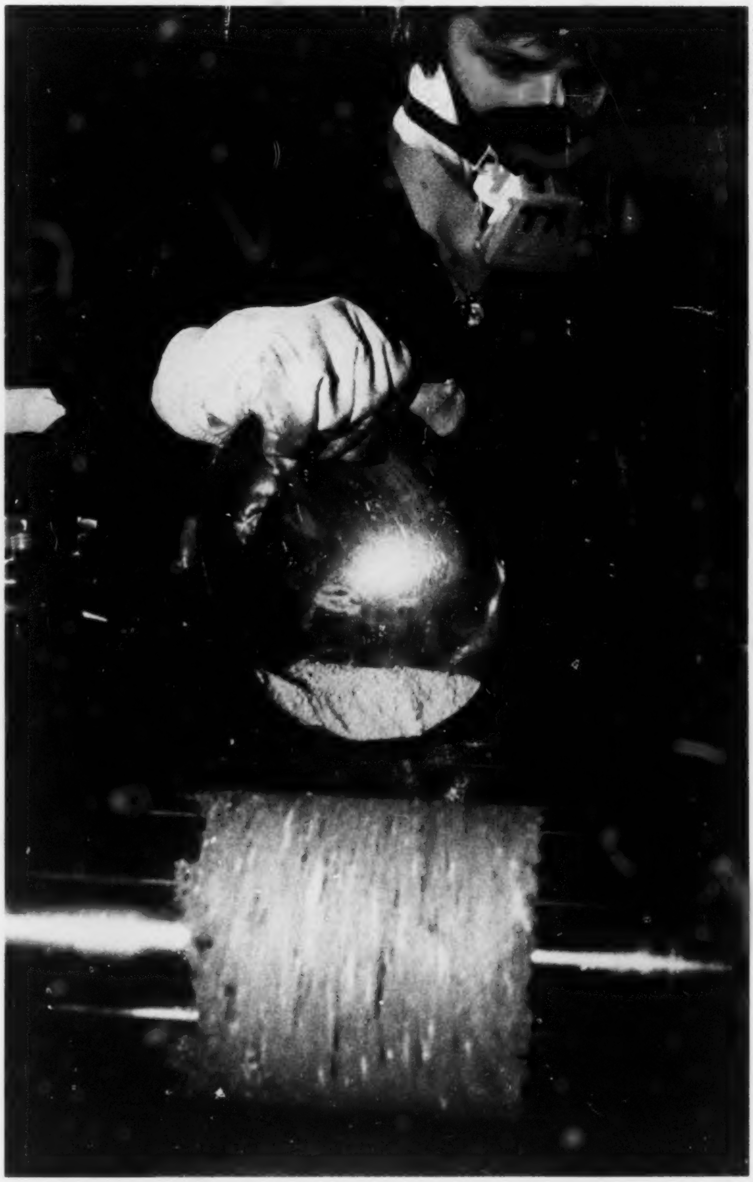
The House does not have the final, only the first, say in setting agency budgets. The Senate is still to be heard from, but that body is usually at least as generous, if not more so, as the House when it comes to funding research programs. ☐

Additives Sales Buoyed By PVC Recovery

Stephen C. Stinson, C&EN New York

Sales of polyvinyl chloride in the U.S. are charging back from a double-dip recession that began in 1979, buoying up with them the fortunes of companies that sell chemical additives to compound PVC. U.S. sales of PVC resin could jump 15% in 1984 to hit a record 6.3 billion lb. Because larger amounts of more additives are put into PVC by greater numbers of compounders than for any other resin, stakes are high on the health of this one plastic.

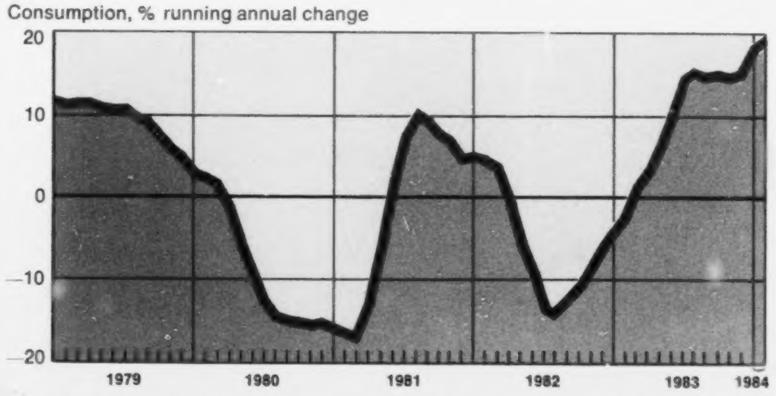
By itself, PVC is a hard, brittle resin that is almost useless, and its thermal instability makes it difficult or impossible to process. That PVC has become a high-volume plastic capable of assuming limitless useful forms is a triumph of chemical innovation. Elliott Weinberg of Cross Gates Consultants, East Brunswick, N.J., points out that properties of PVC are uniquely susceptible to additives, which render it anywhere from rigid and resilient to flexible and supplely draped, and make it useful for applications ranging from a low-cost plastic for novelties to an engineering resin. Because minute changes in additive types and amounts drastically alter processibility and end-use properties, many PVC producers have set up compounding operations, a large number of custom compounders has sprung up, and every processor who does not already compound its own resin ponders the advisability of doing so.


Argus Chemical photo

Argus Chemical technician prepares PVC compound for evaluation

Weinberg, who is also a principal in the PVC technology transfer organization Technical Information Exchange of East Brunswick, says that PVC is an ideal beginning for plastics industries in developing countries. This is because such countries can progress from importing

Polyvinyl chloride surges back from a double-dip recession



Source: Society of the Plastics Industry Committee on Resin Statistics as compiled by Ernst & Whinney

compounds to domestic compounding to resin production. Also, low-cost, low-energy processing techniques are available. A $50,000 extrusion line can make pipe or hose. Liquid dispersions of PVC in plasticizer can be poured into molds for footwear or coated onto fabrics, which are then cured in ovens. And though film calendering lines often cost $5 million to $7 million, film also can be blown from an extruder.

PVC is a success story that might never have happened. The plastic has been beset by problems since its beginning, and new problems have cropped up to the present day. Each problem has been met by a chemical solution, and chemistry will be crucial to meet current concerns over smoke suppression during burning and alleged carcinogenicity of some plasticizers.

Weinberg points out that whereas other resins developed in an orderly manner with a firm underpinning of science, PVC started as an afterthought and grew haphazardly from there. Today there are heat stabilizers that allow melt processing of PVC and use of products at elevated temperatures. But why PVC is unstable to heat, let alone why heat stabilizers work, is the subject of vigorous debate. And although about 100 plasticizers are commercially available, the theory of plasticization is too primitive to predict the improved ones the industry seeks.

PVC was developed by the German company Griesheim-Electron around 1912 in efforts to find uses for then-abundant acetylene illuminating gas. Chemist Fritz Klatte produced vinyl chloride by addition of hydrogen chloride and discovered its polymerization by organic peroxides two years later. Attempts to replace celluloid with PVC foundered over brittleness and heat instability, and in 1926, Griesheim-Electron even stopped paying the fees that maintained its patents.

Rediscovery of PVC happened that same year in the U.S., when Waldo L. Semon of B. F. Goodrich found it could be made flexible by boiling in tricresyl phosphate or dibutyl phthalate. Semon also hit upon white lead as a heat stabilizer, which continues in wide use today. At about the same time, chemists at Union Carbide were trying to find uses for the ethylene dichloride byproduct of ethylene chlorohydrin manufacture. They made vinyl chloride by treatment with sodium hydroxide.

In 1936, Union Carbide started producing vinyl chloride at the rate of 4 million lb per year, most of which went to Goodrich. Also in the mid-1930s, T. L. Gresham of Goodrich tried about 1000 compounds in search of better plasticizers and came up with di-2-ethylhexyl phthalate, which is still the workhorse today.

The long search for chemical ways to enhance workability and properties of PVC continues. For example, current theories of thermal instability propose that there are defect sites inserted into the PVC chain during polymerization that are vulnerable to dehydrochlorination on heating.

In one view of how defect sites arise, disproportionation of radicals could introduce carbon-carbon double bonds that would render chlorine atoms adjacent to them allylic. Heat-provoked eliminations of these chlorine atoms could begin a zipper mechanism, producing more double bonds and new allylic chlorines. The exothermic reaction and hydrogen chloride evolution could then blow the head off an extruder. If unstabilized PVC were extruded safely (which it can be by careful processing on multiscrew machines), further heating during use could continue dehydrochlorination, causing blackening owing to the conjugated polyene sequences generated.

William H. Starnes Jr., a polymer chemist at AT&T Bell Laboratories, Murray Hill, N.J., recently confirmed existence of a long-sought second candidate defect site (C&EN, April 30, page 25). His work suggests that a radical rearrangement forms a side chain on the growing polymer with a tertiary chlorine at the branch point. Tertiary chlorines also might be susceptible to dehydrochlorination and initiation of the zipper cascade.

The controversy continues, with some Soviet scientists suggesting that oxygen present during polymerization could form γ-chlorocrotonyl-type groups in the chain. Such activated γ-chlorines are the real starting points for degradation, they say.

Whatever the nature of the defect site, heat stabilizers seem to act by neutralizing them before they can spark the degradation reaction. Heat stabilizers currently used include lead phosphite, sulfate, or phthalate; mixed barium-cadmium or calcium-zinc soaps or phenoxides; mixed mono- and dialkyltin carboxylates or mercaptides; and antimony mercaptides. During processing, these compounds replace reactive chlorines with less reactive carboxylate, sulfate, phenoxide, or mercaptide groups. Cationic portions take up chloride ions. Stabilizer makers must use care in designing such compounds, because some metal chlorides catalyze dehydrochlorination.

One chloride that does not is lead chloride. The associated nature of lead chloride also imparts good electrical resistance to PVC, leading to wide use of lead stabilizers in wire insulation and cable jacketing, according to William Daly, technical manager for stabilizers at American Cyanamid's Chicago location. Makers of cable jacketing use lead phosphite, he says, because it lends stability to ultraviolet light as well as heat stability to such outdoor applications. Inexpensive lead sulfate goes into wire insulation for service below 90 °C. For use temperatures to 105 °C, lead phthalate is more compatible with the less volatile polyester and trioctyl trimellitate plasticizers used in such insulation. Daly says there is increasing interest in coprecipitated lead sulfate-phthalate, because it could be used in all wire insulation, decreasing the need to keep inventories and install bulk handling systems for several stabilizers.

One outlet that would be a good market for lead stabilizers is PVC pipe. Cost-cutting pressures in this highly competitive field are intense, and lead stabilizers might be more cost-effective. The stumbling block is concern about leaching of lead from pipe used to carry drinking water. Approval of additives for such pipe would have to come from the National Sanitation Foundation. The foundation, based in Ann Arbor, Mich., is a private group formed to police the industry to avoid need for government regulations.

Several lead stabilizer makers have joined under the umbrella of the Lead Industry Association to submit data to the sanitation foundation showing that their products are not leached from pipe in dangerous amounts. Some observers tell C&EN that even if the foundation approves some lead stabilizers, pipe extruders may refrain from using them anyway, because of fears of public reaction. But an approval might still expand use of lead stabilizers for drain, waste, vent, and other pipe that does not carry drinking water. This is because producers of such pipe often also extrude foundation-approved pipe in the same plant and fear contamination of drinking water pipe from another part of the building. Approval of lead stabilizers for drinking water pipe might encourage pipe extruders to use them on their other lines.

What pipe producers do use today as stabilizers are antimony and organotin mercaptides. These products have undergone a tortuous evolution toward ever cheaper, more potent compounds and lower use levels as stabilizer producers have vied for the business of pipe producers. Just as PVC makes or unmakes the fortunes of the plastics chemical additives industry, so pipe of all kinds, which takes 45% of all PVC used in the U.S., rivets the attention of stabilizer producers. American pipe extruders likely will process 2.8 billion lb of PVC this year, using 15 million lb of stabilizers to do so.

The most recently developed type of low-cost pipe compound heat stabilizer is a mixture of the antimony trimercaptide of 2-ethylhexyl thioglycolate with calcium stearate. Known in the industry under the misnomer "antimony isooctylthioglycolate," this product was invented by Weinberg of Cross Gates Consultants when he was at M&T Chemicals, Rahway, N.J., and was further improved by Synthetic Products Co., Cleveland.

The impetus to develop the product, as it has been to improve the tin mercaptides, was the steadily escalating price of tin. The New York tin price rose from $1.67 per lb in 1971 to a peak of $7.73 in 1980, and was still $6.02 in 1983. By contrast, the price of antimony also has fluctuated over the years, but was only 90 cents per lb in 1983. Based on the number of available mercaptide groups in comparison with the also misnamed "dibutyltin isooctylthioglycolate," the antimony content costs only $36.50 per lb-equivalent, versus $357 for tin.

Although a few pipe extruders do use the antimony compound, some suppliers of this stabilizer admit that it has never become wide-

Of PVC consumption, 45% goes for pipe alone

Consumption, millions of lb[a]	
Construction	**3775**
Flooring	350
Panels & siding	305
Pool & pond liners	40
Roofing	30
Pipe & pipe fittings	2805
Windows & other profiles	175
Weatherstripping	45
Other	25
Packaging	**650**
Sheet	125
Film	310
Bottles	175
Closures & other uses	40
Electrical	**475**
Wire & cable	400
Connectors & plugs	60
Other	15
Furnishings	**365**
Upholstery	105
Wall covering	50
Appliances	105
Window shades, blinds & awnings	35
Tablecloths & mats	50
Other	20

Consumption, millions of lb[a]	
Transportation	**235**
Upholstery, trim & tops	135
Floor mats	25
Bumper parts	25
Other	50
Recreation	**195**
Records	105
Toys	45
Other	45
Apparel	**185**
Footwear	95
Handbags	30
Luggage	35
Other	25
Medical	**150**
Tubing	50
Blood & intravenous bags	50
Other	50
Miscellaneous	**290**
Credit cards	25
Garden hose	50
Traffic cones	20
Tool handles	15
Adhesives & sealants	90
Other	90
TOTAL	**6320**

[a] U.S. consumption, 1984.

Heat stabilizers offer trade-off of properties

Suitability rating[a]	Lead	Barium-cadmium soaps	Barium-cadmium liquids	Barium-cadmium-zinc liquids	Calcium-zinc	Dialkyltin carboxylates	Dialkyltin mercaptides
Process stability	3	2	2	2	1	1	3
Process color stability	1	2	2	3	1	1	3
Moderate-temperature color stability	1	3	2	3	1	2	3
Moderate-temperature properties retention	3	2	1	1	1	2	3
Electrical properties	3	2	1	1	0	0	1
Clarity	0	1	3	2	3	3	3
Light stability	3	3	3	3	2	3	0
Toxicity	0	0	0	0	3	3	2
Odor	3	3	1	1	3	2	0
Sulfide stain	0	1	1	2	3	3	3
Cross-stain	0	1	1	2	3	3	0

[a] 3 = best available, 2 = generally suitable, 1 = marginal, 0 = unsuitable. **Source:** Colorite Plastics Co.

spread. This is because it requires reformulation, initially is difficult to get good results with, yields lower pipe output rates, and is less forgiving compared with tin.

The tin stabilizers used in pipe extrusion and processing of rigid PVC generally are based on mixtures of methyltin and dimethyltin or butyltin and dibutyltin. Octyltin-dioctyltin compounds are approved for food packaging and medical applications because they are less extractable. Mercaptide portions have been 2-ethylhexyl thioglycolate, though such so-called reverse esters as β-mercaptoethyl oleate have been found cheaper and more potent, though more odorous, for pipe.

Alkyltin compounds enhance early color retention, whereas dialkyltins promote long-term stability, explains Victor Struber, marketing manager of Argus Chemical division of Witco Chemical. This may be because alkyltins have more mercaptide per mole to cap defect sites than dialkyltins, though the product alkyltin trichloride is a stronger Lewis acid than dialkyltin dichloride and thus would catalyze later blackening if used alone.

Another cost-cutting move has been to lower tin content by using greater than stoichiometric amounts of mercaptoester. In such cases the tin functions as a catalytic carrier. But Argus' Struber cautions that there is a certain irreducible amount of tin needed for effectiveness, perhaps 8%. Stabilizer producers have tried for years to develop all-organic stabilizers with no metal. But hope for success fades as chemists fear that costs of organic synthesis could equal or exceed those of metal.

For flexible PVC, barium-cadmium compounds, with or without zinc, are favored heat stabilizers. Calcium-zinc types go for food packaging or medical applications, though they are less effective. The reason for using these stabilizer types is that they are lower in cost than tins, explains Donald G. Hampson, general manager for thermoplastic additives at the Interstab Chemicals subsidiary of Akzo Chemie America. They do not process so well as tins in rigid compounds, however, so they have not been used much for rigid PVC in the U.S. The plasticizer content of flexible compounds makes them more easily processible, so compounders of these can take advantage of lower costs of barium, cadmium, calcium, and zinc.

Analogous to the tins, cadmium and zinc are good for early color retention, though their chlorides are strong Lewis acids. Barium and calcium contribute long-term stability. Phosphites like tris(nonylphenyl) phosphite and epoxy plasticizers like epoxidized soybean, linseed, and tall oils are synergistic with metal soaps and phenoxides. Stabilizer makers often supply a metal-phosphite blend, and there have been attempts to market metal-phosphite-epoxy combinations. But Struber of Argus points out that compounders' needs are so individual that one ratio of the three would be too limiting.

A recent research push has occurred for stabilizers in PVC blood- and intravenous-solution bags and medical tubing that withstands sterilization by γ-rays. This is because radiation may replace ethylene oxide for sterilization of medical goods. The high flux of γ-rays could initiate radical reactions in PVC that would degrade the resin in ways similar to heat. Most stabilizer makers are reticent to reveal their formulations, but they must be based on such Food & Drug Administration-approved ingredients as calcium, zinc, epoxidized soybean oil, and dioctyltin isooctylthioglycolate. Robert G. Weiler, who is Interstab's business development manager for rigid PVC, says that Interstab gets good results by increasing the content of zinc, epoxidized soybean oil, and antioxidant.

Some of the same compounds that are effective heat stabilizers also function as "kickers" for chemical blowing agents. Azodicarbonamide is the agent most used in PVC. Zinc compounds, especially zinc oxide, are good accelerants. The most potent are compounds of lead, though compounders tend not to use these out of concern for possible toxicity. Rhomie Heck, technical service specialist in plastics blowing agents at Uniroyal Chemical, says that 10% of zinc oxide in azodicarbonamide lowers the blowing temperature to 175 to 180 °C from 210 °C. Blowing agents usually are used with plastisols, which are liquid dispersions of PVC in plasticizer. For these, it is important that the blowing temperature of the blowing agent match the curing temperature of the plastisol. Plastisol processors generally work at temperatures from 150 to 200 °C.

In addition to stability to heat, outdoor applications of PVC sometimes require UV absorber additives to protect against sunlight. In pigmented, pastel applications like some vinyl siding, window frames, and building panels, a 15 to 20% loading with titanium dioxide is protection enough. For clear, translucent, or darkly pigmented PVC, high loadings of titanium dioxide are ruled out, and the UV absorbers

A history of polyvinyl chloride

1835. Justus von Liebig at the University of Giessen discovers that reaction of the "oil of the Dutch chemists" (ethylene dichloride) with alcoholic potash produces a chlorine-containing gas. Liebig assigns confirmation of the work to his student, Victor Regnault, and lets Regnault publish as sole author. As a result, Liebig is forgotten as the discoverer of vinyl chloride.

1872. E. Baumann finds that exposure of vinyl chloride to sunlight in a sealed tube produces a white solid that resists attack by potassium hydroxide or water and melts with decomposition above 130 °C.

1912. Chemische Fabrik Griesheim-Electron gives chemist Fritz Klatte the task of finding uses for acetylene, and he develops commercial synthesis of vinyl chloride by addition of hydrogen chloride.

1915. Klatte finds that organic peroxides initiate polymerization to polyvinyl chloride.

1926. After years of effort to develop rigid PVC as a replacement for celluloid, German workers have failed to build machinery that will process the resin and have not overcome the problem of thermal instability. Griesheim-Electron stops paying the fees that maintain its patents. Meanwhile in the U.S., Union Carbide, looking for uses for the ethylene dichloride by-product of chlorohydrin production, converts it to vinyl chloride with sodium hydroxide. PVC also interests Waldo L. Semon at B. F. Goodrich, who is looking for an adhesive to bond rubber to metal. Semon observes that boiling PVC in such liquids as tricresyl phosphate or dibutyl phthalate renders it highly elastic, thus discovering plasticizers. In addition to molding parts from plasticized PVC, Semon goes on to coat wire, cloth, and metal parts with solutions of PVC in plasticizer or plasticized PVC in organic solvents, thereby inventing plastisol and organosol processing techniques. He uses white lead and sodium silicate as heat stabilizers.

1928. Union Carbide and Du Pont each find that copolymers of vinyl chloride with vinyl acetate have improved processibility.

1934. Frazier Groff of Union Carbide discovers that alkaline earth soaps stabilize PVC to heat.

1936. Union Carbide's PVC homopolymer plant comes on stream at 4 million lb per year. Chemists there find that dialkyltin soaps are also heat stabilizers. At B. F. Goodrich, T. L. Gresham tests thousands of compounds before settling on di-2-ethylhexyl phthalate as the best plasticizer.

1941. During World War II, PVC is commandeered for military use, with the Navy in particular using large amounts of phosphate-plasticized, fire-retardant wire insulation developed by General Electric.

1947. One or more workers now unknown hit upon synergistic combinations of barium, cadmium, calcium, and zinc soaps as heat stabilizers.

1952. Elliott Weinberg at Metal & Thermit Corp. invents the dibutyltin dimercaptide with 2-ethylhexyl thioglycolate as a heat stabilizer for rigid PVC, and at the same time invents the antimony trimercaptide low-cost stabilizer for pipe, which will be commercialized 30 years later as tin prices skyrocket.

1960. U.S. production of PVC tops 1 billion lb.

1970. Pier Luigi Viola at Regina Elena Institute for Cancer Research in Rome finds that exposure to very high levels of vinyl chloride vapor causes ear tumors in rats. U.S. production of PVC tops 4 billion lb.

1973. Cesare Maltoni, working for a group of European firms at the Institute of Oncology in Bologna, Italy, finds that inhalation of vinyl chloride vapors causes rare angiosarcoma liver cancer in rats. The Manufacturing Chemists Association is allowed to see his work, but only under a confidentiality agreement. Forbidden to communicate Maltoni's findings, MCA commissions its own studies of rats and worker exposures. Late in the year, physician John L. Creech links deaths of two B. F. Goodrich workers from angiosarcoma to vinyl chloride exposure in Louisville, Ky. Eventually, angiosarcoma deaths of three dozen people worldwide are tied to vinyl chloride exposure.

1974. Goodrich tells the National Institute of Occupational Safety & Health of the cancer link. The Occupational Safety & Health Administration reduces permissible vinyl chloride exposure to 50 ppm from 500 ppm and proposes a "zero detectable limit." Industry spokesmen say that will force them to shut down. OSHA agrees to a phased reduction to 1 ppm. PVC makers announce that they can meet this and alter their plants to do so. Later, activists tar industry for saying first that the OSHA limit would shut them down and then agreeing that they can meet it.

1980. The National Cancer Institute finds evidence that di-2-ethylhexyl phthalate plasticizer causes cancer in rats and mice.

1982. Stung by inroads of PVC into pipe, metal-pipe makers counterattack with a campaign to warn public authorities of toxicity of gases emitted by PVC in fires.

1984. A recovering U.S. economy carries PVC use to a record 6.3 billion lb.

most used then are benzophenones and benzotriazoles. Also used are such acrylates as 2-ethylhexyl 2-cyano-3,3-diphenylacrylate, which are also called acrylonitriles.

According to Joseph Stretanski, who is technical manager for plastics additives for American Cyanamid, benzophenones such as 2-hydroxy-4-methoxy- or 2-hydroxy-4-octoxybenzophenone usually are used in conjunction with barium-cadmium stabilizers, and such benzotriazoles as 2-(2-hydroxy-5-*tert*-octylphenyl)benzotriazole are used with tins. Benzophenones are yellow and contribute color to a clear vinyl compound. In applications such as a clear vinyl coating for a richly colored flooring tile, the slight yellowing may not matter. Benzotriazoles perform better than benzophenones and yield clear vinyl products that are water-white. So some

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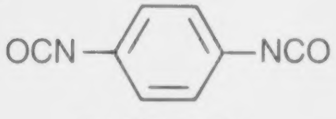

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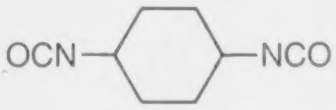

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processors prefer benzotriazoles, despite their higher cost, than many benzophenones.

Despite the great attention given to developing chemical additives to stabilize PVC in processing and in use, plasticizers are the additives that are used in greatest amounts for this resin. In recent years, applications for rigid PVC have grown faster than for flexible PVC, as in the invasion of the pipe market. Still, as Edward J. Wickson reminded the CAN-AM Chemical Congress earlier this month in Montreal, more PVC is processed on a flexible compound basis than is rigid. Wickson is chief products applications scientist at Exxon Chemical's intermediates technology division in Baton Rouge. He told his Montreal listeners that in 1982, the U.S. used 3.0 billion lb of plasticized compounds, containing 2 billion lb of PVC and 1 billion lb of plasticizers, compared with 2.6 billion lb of rigid compounds.

Since the emergence of di-2-ethylhexyl phthalate ("dioctyl phthalate," or DOP) as plasticizer of choice 50 years ago, researchers have tried to find new ones to replace it. Wickson used figures of the U.S. International Trade Commission to document that they have been partly successful, as DOP declined to 25% of total U.S. plasticizer use in 1982, compared with 42% in 1972. New plasticizers have been found, usually costing more than DOP, but superior to it in extractability, volatility, low-temperature flexibility, or fire retardance. Still, Wickson made a case that his firm's diisononyl phthalate is slightly more cost-effective than DOP.

Plasticizers are liquids that are absorbed by PVC particles during compounding to produce dry, free-flowing powders or pellets even at high use levels, when there may be much more plasticizer than resin. Processing these compounds produces a close physical association among plasticizer molecules and PVC chains to yield flexible films and objects from which a good plasticizer does not exude. Even a "worm" made as a fishing lure from highly plasticized PVC is dry, despite its realistic feel. Although plastisols are processed as liquid, dispersions of PVC microparticles in plasticizer cure to dry parts on oven curing.

Plasticization and the efficacy of plasticizers are as much mysteries as the heat instability of PVC and the workings of heat stabilizers. Vincent P. Kuceski has described the lubricity, gel, and free-volume theories of plasticization in American Chemical Society Short Courses. Kuceski, who is vice president of research and development at C. P. Hall Co., Chicago, says that plasticization in the lubricity view is the dissociation of crystalline regions of polymer by plasticizer molecules. To be efficient at this,

Plasticizer choice depends on properties desired

Relative performance rating[a]	**General-purpose phthalates**	**High-molecular-weight phthalates**	**Epoxidized soybean oil**	**Trioctyl trimellitate**	**Polyesters**
Exudation[b]	5	3	2	4	1
Humidity resistance	5	3	2	4	1
Acid resistance	5	4	2	3	1
Dry-blend mixing rate	5	3	2	4	1
Melt-mixing fusion rate	5	2	1	4	3
Plastisol viscosity	5	3	2	4	1
Volatility[b]	1	2	4	5	3
Light stability[b]	5	3	1	4	2
Migration resistance[b]	1	2	4	3	5
Extraction resistance (kerosine)[b]	2	1	4	3	5
Fungus resistance[b]	4	3	2	5	1
TOTAL RATING	**43**	**29**	**26**	**43**	**24**
PERMANENCE RATING TOTAL	**18**	**14**	**17**	**24**	**17**

a 5 = best, 1 = poorest. b Measure of permanence. **Source: Nuodex** the plasticizer must be compatible with the resin overall, but not too good a solvent. This is because plasticizer molecules serve as physical "spacers" among PVC chains.

In the gel theory, PVC stiffness arises from points of intermolecular attraction among chains, caused perhaps by association of polar carbon-chlorine bonds, or from chain entanglements. Plasticizer molecules might then neutralize bond polarity or intercalate among chains to break up entanglements. To do this, the plasticizer must be a fairly good solvent for PVC to prevent the plastic from "precipitating out."

In the free-volume theory, thermal motions of small, mobile plasticizer molecules increase the amount of volume in the matrix by an amount greater than they themselves occupy at a given instant. PVC chains are free to use this volume to increase their mobility. But plasticizers can do this only if they are not very good solvents for PVC, because plasticizer molecules must be free to move and increase free volume rather than be constrained by interaction with PVC chain sites.

Prices of plasticizers vary widely

1982 price, $ per lb	
Aromatic	
Di-2-ethylhexyl phthalate	$0.40
Diisodecyl phthalate	0.42
Di-*n*-octyl phthalate	0.37
Ditridecyl phthalate	0.63
Tri-2-ethylhexyl trimellitate	0.65
Aliphatic	
Di-2-ethylhexyl adipate	0.61
Di-2-ethylhexyl sebacate	1.50
Polymeric	0.96
Epoxy	
Epoxidized linseed oil	0.83
Epoxidized soya oil	0.48
Fire retardant	
Chlorinated paraffin,	
35 to 64% chlorine	0.37
65% chlorine and up	0.52
Phosphate esters	0.50
Polyvinyl chloride[a]	0.24

[a] Included as reference. **Source:** U.S. International Trade Commission

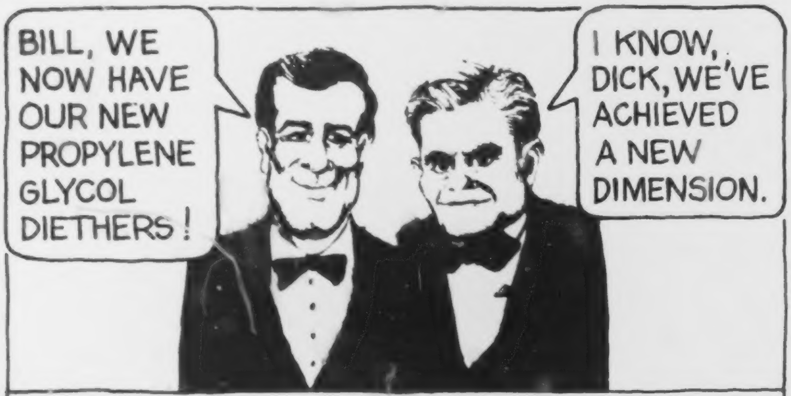
Despite progress in understanding plasticization, Kuceski says that chemists are far from being able to calculate how much of a given plasticizer to use to lower the glass transition temperature of PVC by a desired amount or to predict what compounds would be good plasticizers. He suggests that it may be possible to develop a computer program to do this that would take into account solubility parameters, free volume, and donor-acceptor values of species involved in dipole-dipole interactions.

Plasticizers are classified as primary or secondary. Primary plasticizers are very compatible with PVC and can be used as sole plasticizers. These tend to be aromatic, aliphatic, epoxidized, or phosphate esters. Secondary plasticizers have low efficiency or compatibility with PVC and only supplement primary ones. Examples are hydrocarbon oils, added to reduce costs, or chlorinated paraffins for fire retardancy.

As criteria for plasticizer selection, Kuceski cites compatibility, permanence, performance at low temperatures, efficiency, processibility, esthetic and physical properties, durability and stability, and cost. He defines compatibility as ability to form a homogeneous mixture with PVC that does not exude plasticizer from finished product. Compatibility is enhanced for branched-chain, compact, or low-molecular-weight molecules, and by presence of ether or polyester groups. It is greater at high temperatures for monomeric plasticizers and at low temperatures for polyesters.

To Kuceski, permanence includes resistance to physical changes by heat, humidity, solvents, oils, and weather that might volatilize or extract plasticizer or cause migration to another polymer. Others in the plasticizer industry include chemical changes by heat, weather and light, salt water, chemical attack, fungus, and bacteria. Kuceski uses the term durability and stability to describe resistance to such chemi-

Continued on page 47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Efficiency is the amount of plasticizer that must be used to get a desired value of properties such as glass transition temperature or a 1500-psi modulus at 100% elongation. Low-molecular-weight, aliphatic plasticizers enhance efficiency.

As for durability and stability, branched chains are less susceptible to bacterial or fungal attack than are linear esters. Fatty acid derivatives used as lubricants in PVC compounds also are subject to attack. For PVC film and parts to be used in humid environments, compounders add a biocide. The one most used is 10,10′-oxydiphenoxarsine, though there is some use of trialkyltin compounds too. Plasticizer oxidation also can occur at high processing temperatures, and Kuceski says that his firm sometimes adds antioxidants to plasticizers.

Though FDA approval is unnecessary for all applications, there are plasticizers that have wide approval for food packaging and medical uses. These include di-2-ethylhexyl phthalate, adipate, and sebacate, many polyesters, and epoxidized oils. There has been concern over possible carcinogenicity of di-2-ethylhexyl phthalate and adipate. Speaking in Montreal, Exxon Chemical's Wickson reviewed findings of the National Cancer Institute that these compounds are carcinogenic in rats and mice. But Wickson also pointed out that work at ICI suggests that di-2-ethylhexyl phthalate metabolism is different in primates. The Chemical Manufacturers Association has commissioned a study of plasticizer toxicity and carcinogenicity. FDA has not yet changed the regulatory status of 2-ethylhexyl esters, but some processors have begun evaluating other phthalates and adipates as a precaution.

Di-2-ethylhexyl phthalate has con-

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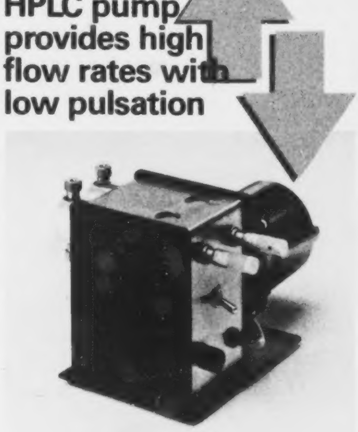

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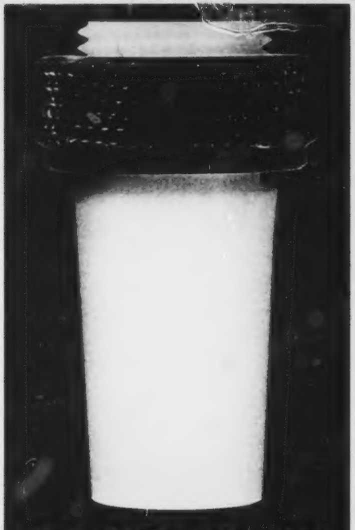

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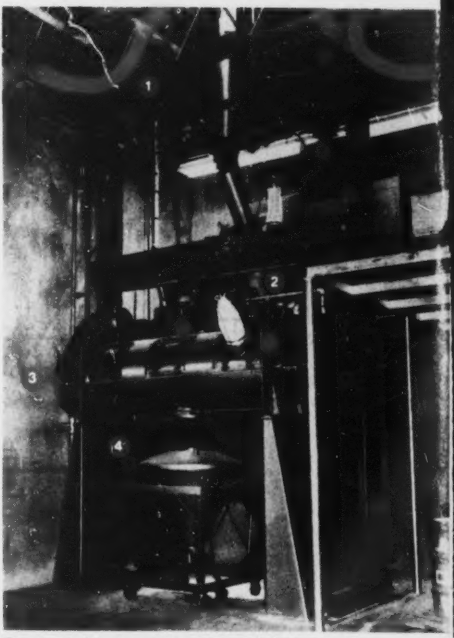
tinued in wide use over the years because it is still the low-cost plasticizer. Nevertheless, as Wickson says, PVC has moved into high-performance markets that require better properties than general-purpose phthalates can give. These uses include single-ply roofing membranes, water bed heaters, automotive crash pads, refrigerator gaskets, electrical tapes, and oil-resistant cable. In addition, Underwriters Laboratories will issue new standards on residential wire insulation late this year, raising ratings to 90 °C from 60 °C and require heat-aging tests at 136 °C rather than at 100 °C as at present.

But as plasticizers impart flexibility to PVC, they also raise its flammability. The high chlorine content of rigid PVC makes it fire resistant enough not to need fire retardant additives. Compounding large quantities of plasticizer into the resin decreases the average chlorine content, however. Fire retardants most often used in flexible PVC are antimony oxide and phosphate ester and chlorinated paraffin plasticizers.

Antimony oxide is synergistic with the chlorine content of PVC, explains Philip Rakita, who is marketing manager at M&T Chemicals in Rahway, N.J. Antimony trichloride is thought to be formed as the plastic is heated. Vapors of this compound may stop the free-radical reactions of combustion. The oxide itself is a white pigment, however, and cannot be used in applications intended to be clear or pigmented in dark colors. M&T and other firms have gotten around this by offering sodium antimonate, which is not a pigment; antimony oxide of larger particle size, which does not have as much hiding power; and antimony pentoxide, which as a colloid also is not a pigment.

Chlorinated paraffins and such phosphates as tricresyl phosphate also make no contribution to compound color. Both types of fire-retarding plasticizer are used to replace only part of the plasticizer usually used, because of the poor compatibility of chlorinated hydrocarbons and the relatively high price and low efficiency of phosphates. Chlorine in chlorinated paraffins is synergistic with any antimony oxide used, but M&T's Rakita says that phosphate esters and antimony impede one another's fire-retarding action.

Dry blending yields low-cost powdered compounds



Littleford Brothers photo

Resin falls from hopper (1) into vertical, cylindrical, high-intensity mixer (2) where additives also are placed. Hot dry-blend is fed into a cooling mixer (3), from which the cooled powder exits to another hopper (4) for fabrication

Having chosen the types and amounts to be used, the compounder next blends them with resin on an appropriate machinery line. Both rigid and flexible PVC compounds end up as solids, either pellets or powder, to be sent to such fabricating equipment as injection molding machines, extruders, or calenders. To produce a plastisol, the compounder uses a dispersion-grade PVC whose particle sizes are 20 μm or less. The result of mixing with

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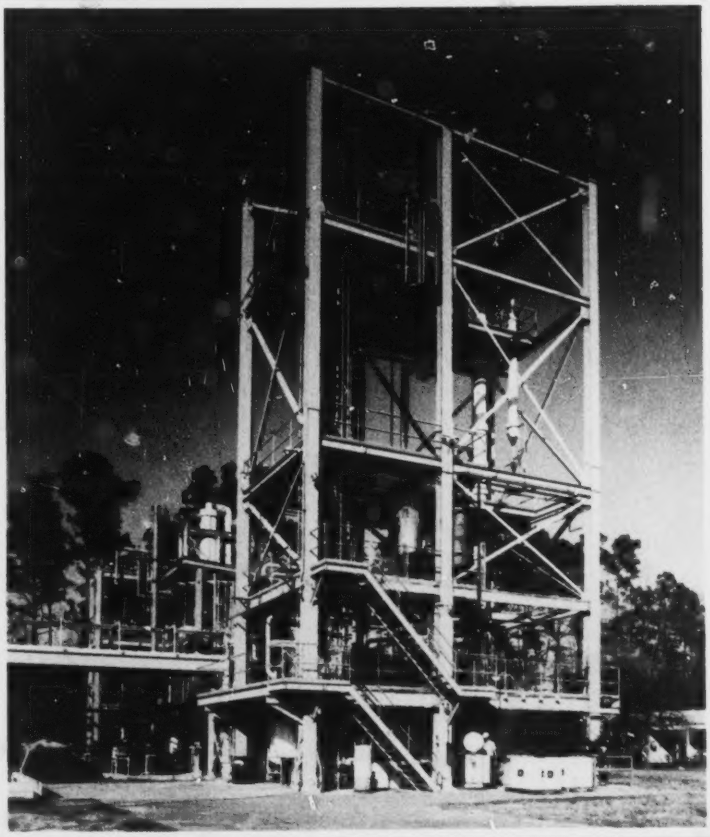
plasticizers and other additives is a viscous liquid that can be processed by techniques like spraying, dipping, knife or roll coating, and rotational and slush molding.

According to Cross Gates Consultants' Weinberg, PVC fabricators often prefer pelletized compound. This is because pellets are versatile, suitable for short runs. They are easier to store for long periods, to convey in materials handling equipment, to blend with any reground scrap or trim, and to fabricate with inexpensive, less sophisticated, conventional equipment. And pellets can be calendered, whereas powder cannot. In addition, though there are custom compounders that will supply powder, most fabricators who buy compound outside will buy pellets, and the supplier's quality control will make that of the buyer simpler. A disadvantage of pellets is that they are melt compounded, which adds more total exposure to degrading heat.

But above a certain use level, Weinberg says, it can be less costly to dry-blend powder in-house than to buy pellets outside. Dry blending subjects the compound to less total heat exposure and the mixers use less energy than the melt mixers needed for pellets. Also, with enough trial-and-error compounding as well as use of multiscrew injection molding machines or extruders to fabricate, compounders can get the same quality product at the same output rates as with pellets. Multiscrew machines use large amounts of shear and less external heating to produce homogeneous melts under mild conditions.

Whether dry- or melt-compounded, high-intensity mixing or premixing is often best. This is because such mixers volatilize excess vinyl chloride from the compound. Many high-intensity mixers are available for dry-blending PVC. One popular type is that of Littleford Brothers, Florence, Ky. A first mixer uses shear energy of blades to raise compound temperatures to 95 to 115 °C for complete absorption of plasticizer by PVC granules. This discharges into a cooling mixer, which rapidly drops compound temperature to 50 °C to densify the powder, render it more free-flowing, and avoid excessive exposure to heat.

Blades in the vertical, cylindrical, high-intensity mixer generate a vortex that moves the powder upward along the inner wall. At the top of the vortex, the blades throw the powder to the bottom, where it is again carried upward along the wall. In the horizontal, cylindrical cooling mixer, heat is removed by water circulating in the jacket, which is long and narrow to maximize contact surface. High-intensity mixing takes four to 10 minutes, depending on batch size. Cooling takes slightly less time, matched to exceed batch output rates of high-intensity mixing. The cooling mixer discharges either into a hopper container for



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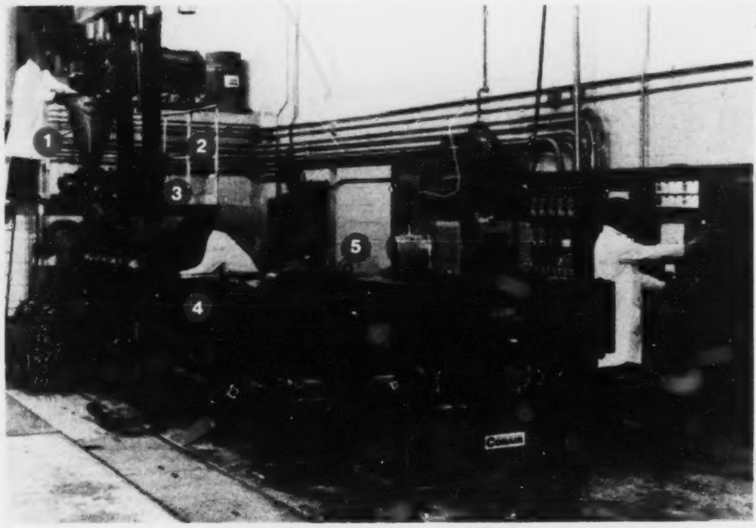

Alloy Polymers photo

Resin already blended with some additives in a high-intensity mixer enters a twin-screw extruder (1) through a hopper. Additional fillers and colorants enter the extruder barrel (2). Then strands or sheet of compound exit the extruder through a die (3). A trough of water (4) cools the compound. Finally, a pelletizer or dicer (5) chops the compound strands or sheet

storage or to be taken to fabricating machines. Alternatively, cooled compound is transported overhead to production lines by an air-driven materials handling system.

Again, there are many systems for melt-compounding PVC. One popular type is a twin-screw compounding extruder of Werner & Pfleiderer Corp., Ramsey, N.J. Segmented construction of screws and barrels allows custom construction of the exact type needed. Multiscrew compounding adds more shear work to the compound, mixing it homogeneously without need for excessive external heating.

A second popular type is the single-screw kneader of Buss-Condux, Elk Grove Village, Ill. Screw flights are interrupted by gaps, and the extruder barrel is studded with teeth to match the gaps. As the screw turns, it also moves back and forth, producing both a mixing by shear against screw flight and barrel surfaces and a kneading by the teeth in the screw flight gaps. Such a machine operates at lower temperatures than ordinary single-screw machines because of lower internal pressures developed and because of controlled heating or cooling by circulating oil in the barrel and screw.

Product from the compounding extruder is pelletized or diced. Spaghettilike strands from the many holes in the extruder die are chopped into pellets, which drop into a container where they are fluidized and cooled by air. Alternatively, an extruded ribbon of compound passes through a long trough of cooling water, followed by dicing at the end.

High-speed mixers serve to disperse PVC in plasticizer to make plastisols. An example is that of Day Mixing, Cincinnati. A knife-edge rotor in the bottom of the vertical cylinder spins at 9000 rpm and sets up a vortex of liquid, which impinges against baffles set in the inner wall. In addition to the rotary motion, there is convection of liquid up the inner walls of the mixer and down the interior of the vortex to contact the rotor. Cooling water at 15 °C in an outer jacket keeps plastisol temperatures safely below 35 °C. At the end of a 15-minute mixing cycle, a vacuum of five minutes' duration deaerates the plastisol. □

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CHEMICAL & ENGINEERING
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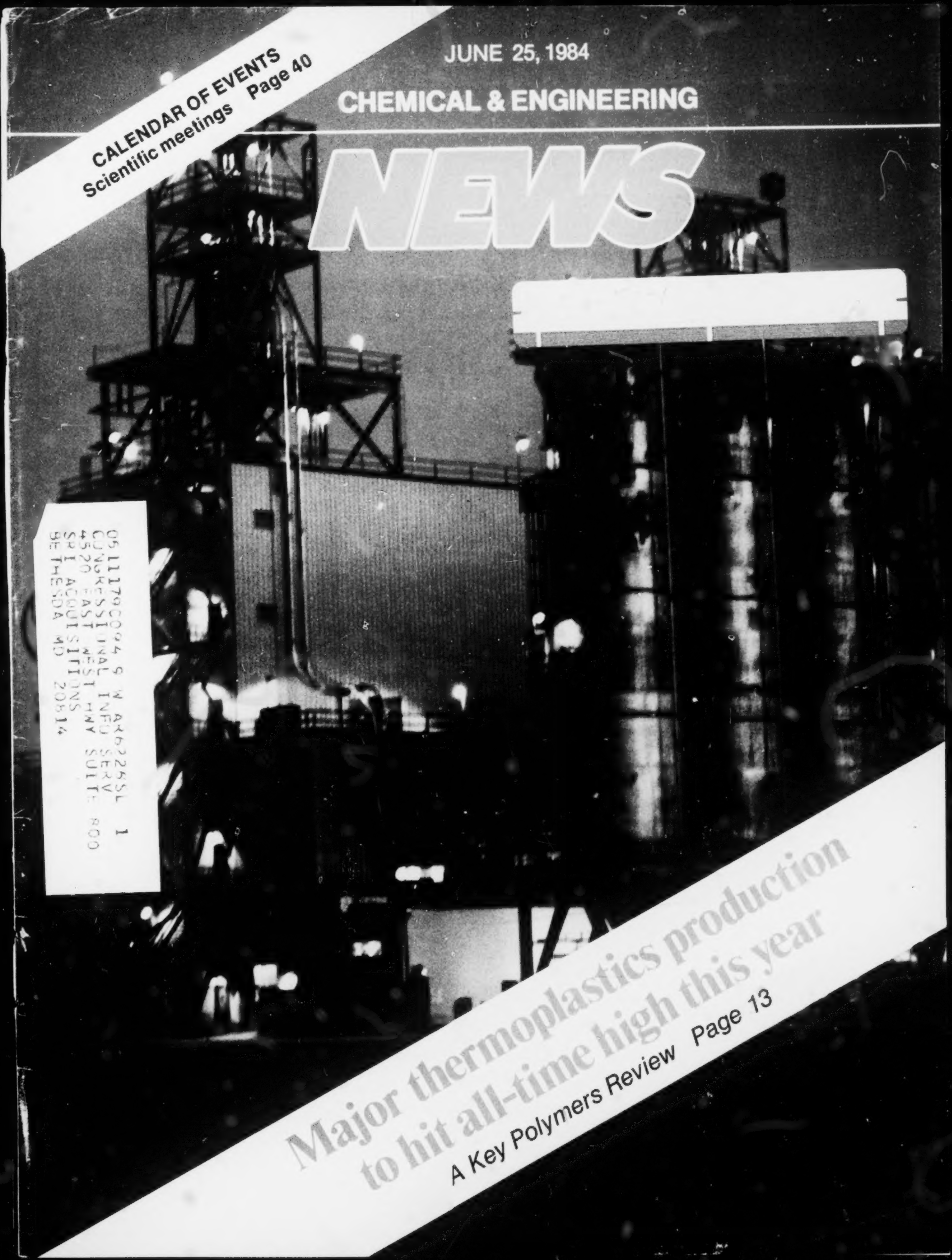

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Major thermoplastics production to hit all-time high this year

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CHEMICAL & ENGINEERING
NEWS

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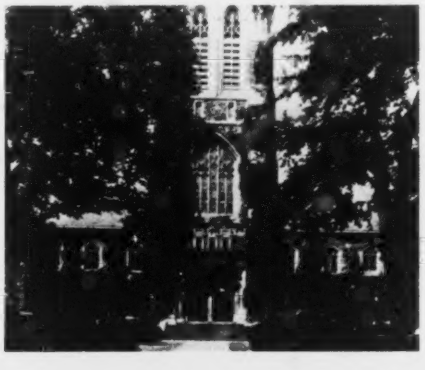


News Focus

University research capitalized by industry is the target of critics who claim ethics, social values are ignored. **Page 7**

University/Industry Research Ties Still Viewed with Concern

Critics insist that universities are violating obligations to science and society by marketing expertise to industry; small colleges feel left out of trend

Wil Lepkowski, C&EN Washington

Interest appears to be rekindling around the issue of "collegiate capitalism," or more specifically, the impact of industrial money on the identities of university researchers and their institutions.

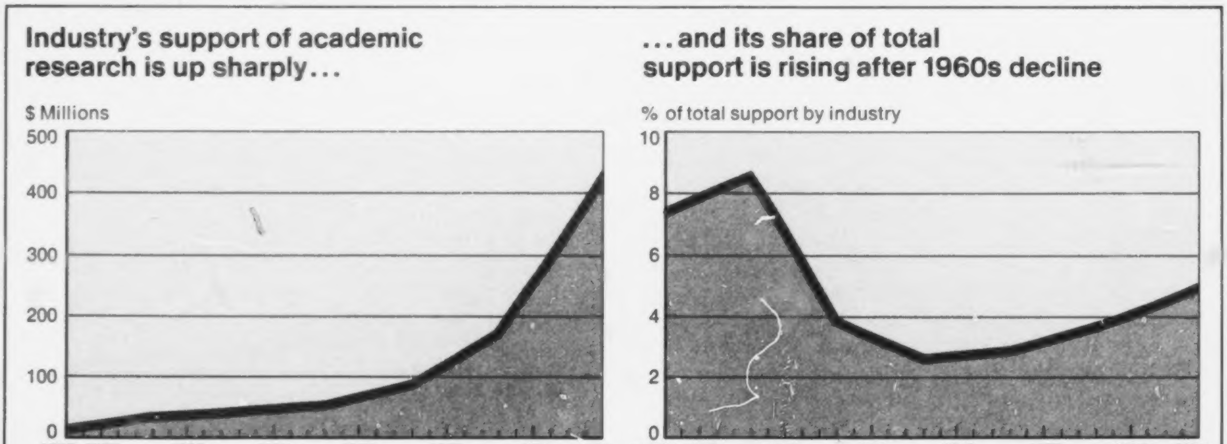
Arguments are being refined, regulations and laws are being examined, university policies are being formed or reworked—all to explore what mutations the research universities are undergoing in their quest for the corporate dollar.

New laws passed by Congress and federal sponsorships of cooperative research between industry and academia hurry it along. A key spur is the right of universities to license their federally funded technology on an exclusive basis to corporations. A further catalyst is the campaign by states to spin their economic development around research parks funded by industry and staffed mainly by university scientists.

"Some may think the conflict of interest issue has waned, but I don't think so at all," says John D. Holmfeld, a senior staffer for the House Science & Technology Committee. "We've seen no overt scandals, but we're just waiting for the next unfortunate incident to occur. I can visualize some professor with a stake in a corporation withholding information from his colleagues by refusing to publish, pending patent protection, then having colleagues blow the whistle on him or her. There are many out there in academia looking for instances."

One of the leading professorial critics of the phenomenon is Sheldon Krimsky, associate professor in the department of urban and environmental programs at Tufts University. He believes that the involvement of biologists in the university/industrial complex is especially unfortunate.

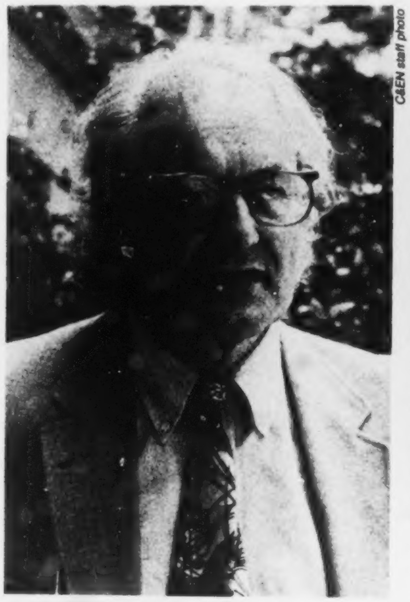
"The types of university-industry relationships in biology are more varied, more aggressive, more



Industry's support of academic research is up sharply...

...and its share of total support is rising after 1960s decline

Source: National Science Foundation



C&EN staff photo

Minsky (left): populist values should reign. Starr (above): small colleges deserve more. Rosenzweig: keep the federal government out

experimental, and more indiscreet than they had been in similar historical circumstances," he says. "A significant number of new firms in biotechnology sprung out of academia. The intense commercialization of biology could result in an enormous social liability," he believes.

The development of the commercial mind-set in academia takes insidious directions, Krimsky believes. "The new values emphasizing science for commerce become internalized and rationalized as a public good," he theorizes. "It happens incrementally, without conspiracy or malice. Scientists and engineers with a stake in the commercial outcome of a field cannot at the same time retain a public interest perspective that gives critical attention to the perversion of science in the interests of markets. If you have too many scientists involved with corporations, how can the public have confidence that those scientists will provide objective expertise when biotechnology becomes, as it is, an environmental and public health issue? The result could be a scarcity of disinterested experts when controversial issues reach the public policy stage."

The issues will be examined over coming months by Ralph Nader's new group, the Center for Universities & the Public Interest, headed by former educator Leonard Minsky. The center was formed only three months ago and is in the process of incorporating as a nonprofit institution.

The goal of the new center, says Minsky, "is to oppose the industrialization and 'corporatization' and the militarization of research in universities. We're also opposed to any attempts made by the ideological Right to use universities to give a gloss of credibility to what are essentially ideological positions. We're going to try to show in concrete instances what the alternatives have been and will be if corporations and the military have their say in setting the agenda for the universities."

Minsky says he plans to begin a membership drive this fall. The working agenda will include meetings, conferences, speeches, and the launching of a major "Nader raider" type investigation of abuses of the academic ideal. That will begin, he says, in a little more than a year. "We hope to be able to offer community groups information on subjects concerning their difficulties with environmental problems impacting the community that have an ideological dimension. We will draw most of our support from academics who now are powerless and support from the community once we have shown our usefulness. We believe there are hundreds of instances of faculty [members] who are fired for their views. We mean to bring home to scientists the social consequences of their work."

Says Minsky in a perspective paper he has just written: "When university researchers are en bloc consultants, when funds are specifically tied to the generation of commercially useful products, and when corporate scientists effectively choose the topics of research for university scientists, we have reached an entirely new level of corporate control. The profit motive must now necessarily dominate the consciousness of professors and students alike."

Minsky's ideas come from his own populist perspective. But establishment academics are no less critical.

Eric Holtzman, chairman of the department of biological sciences at Columbia University, thinks the problem is getting more serious for two reasons. The first is that because of the privatization of knowledge, needed biological information could be withheld from developing countries where it could be used effectively. The second is the more often expressed concern that scientists are clamming up in the sharing of information about what he calls "tricks of the trade," or laboratory methodologies in areas such as gene splicing or fermentation.

Holtzman acknowledges that chemistry and physics have adapted the respective ethoses to commercial realities and have adapted their own rules of the game. "My fear," he says, "is that the biological modus vivendi will corrode what has been an open society in biology."

At present, he doesn't think it will be possible to get any detailed data on the degree of involvement. "It's a matter of small decisions being made by a large number of people in numerous circumstances," he says. Biologists are "sworn to secrecy" in occasional collaborations. Violations of the tradition of openness have occurred to a minor degree so far, he says. "But it's in the air; people are talking about it."

Holtzman says that three things can be done to prevent monopolization. First, international flow of knowledge to developing countries, where it's most needed, has to be facilitated. New organisms important for medicine and agriculture should not be national or private property.

Second, Holtzman believes new forms of biotechnology production facilities need to be developed, not entirely public, not entirely private. They would be experimental at first and would operate under the principle that the new biology represents a massive public investment and therefore needs to be put under some public control.

But that wouldn't be the only reason. Just as important is the principle that the new biology has immense long-term implications and therefore should not be guided by the short-term interests of traditional mercantilism. Just what these new "biological utilities" would look like is far from clear. But they would require lots of thought, small-scale experimentation, and therefore most likely legislation, Holtzman believes.

And third, he says, scientists have to start talking about the dangers more among themselves. They need to discuss the long-term health of their enterprise. "People are tangentially aware of the problem," he says, "but it hasn't really come home to them yet."

John C. Chester, assistant to the general counsel at the National Science Foundation, says the foundation is about to launch an inquiry into whether its grant recipients who also have corporate ties are suppressing data because of allegiance to their corporate sponsors. For example, suppose the privately and publicly funded research overlaps. And suppose the research results are patentable. Does the scientist have the right to withhold the information until the patent is filed?

"Questions come up with respect to how much work that a person does should be reported and made available," he says. "Right now NSF has a laissez faire attitude. Nothing leads us to suspect it is not true. We hear stories, especially in biotechnology, where a patent attorney is standing by a scientist at a meeting, telling him or her what to and what not to say for fear of revealing patentable information."

One academic scientist, John E. Gander, chairman of the department of microbiology and cell science at the University of Florida, is distrustful of any deep government intervention of that type. At the same time, he acknowledges that the amount of faculty involvement with industry is much more extensive than the public is aware of.

"The problem we are talking about is basically one of human behavior," he says. "There will always be people who will try to manipulate the system for their own ends. And complex bureaucracies would allow a conflict of interest to be buried so deep that it wouldn't be detected. Others less savvy may slip up. And when they do, the whole community will be discredited. The best thing that one can say about what should be done is that people in science who are not involved with industrial ties should get together and set up sets of principles or regulations, not the bureaucrats. This would be a process parallel to the peer review system."

Joseph E. Varner, a biochemistry professor at Washington University who does considerable consulting with nearby Monsanto, says the principal place where conflict of interest arises is where graduate students may be doing work related to the industrial program. "So we here simply don't have students work on any of the projects with Monsanto. We also have some grant money from Monsanto where there are no strings attached. But we don't support graduate students on that, either.

"But with postdoctoral students and faculty, Monsanto wants to have a rough draft of a paper a month ahead of the time it is to be submitted to a journal. So far, there's been no trouble at all. We do the fundamental work we propose to do.

"In the consultant work, we do see privileged information and it is up to our own good sense and judgment to avoid using that information in our own research. We do see sensitive stuff and if we get into trouble, it's our own fault. But consultants have always had that problem.

"On equity positions with companies, I know I'm hopelessly out of date on this, but I don't think any

Virginia Polytechnic has largest share of industry-supported research

Rank[a]		R&D expenditures[b] ($ millions)	Total from industry ($ millions)	Per cent
59	Virginia Polytechnic Institute	$39.9	$6.5	16.3%
26	Georgia Institute of Technology	71.4	11.4	16.0
99	Rensselaer Polytechnic Institute	20.3	2.8	14.0
63	Carnegie-Mellon University	37.4	4.8	13.0
24	Pennsylvania State University	82.0	10.6	12.9
46	Colorado State University	46.6	5.1	11.0
30	Purdue University	67.3	7.4	11.0
96	Brown University	21.3	2.2	10.5
87	Clemson University	23.5	2.3	9.8
21	University of Arizona	88.2	8.6	9.7
2	Massachusetts Institute of Technology	157.2	17.2	8.9
42	University of Miami	51.9	4.6	8.9

a In total R&D funding. b Amounting to $20 million or more as of fiscal 1982. **Source:** National Science Foundation university professor ought to be in the position of making money on his own work if he's already been bought and paid for by NIH or NSF. So it's only common sense and good ethics to go back to public responsibility."

The key issue, according to Howard W. Bremer, patent attorney for the Wisconsin Alumni Research Foundation (the patenting, marketing, and licensing organization for University of Wisconsin research), is that the university doesn't wind up being a research arm for industry: "That may be an incursion on academic freedom." There are no spectacular legal battles occurring right now, Bremer says, but there could be in the future, or if not that, at least a lot of pain for the universities.

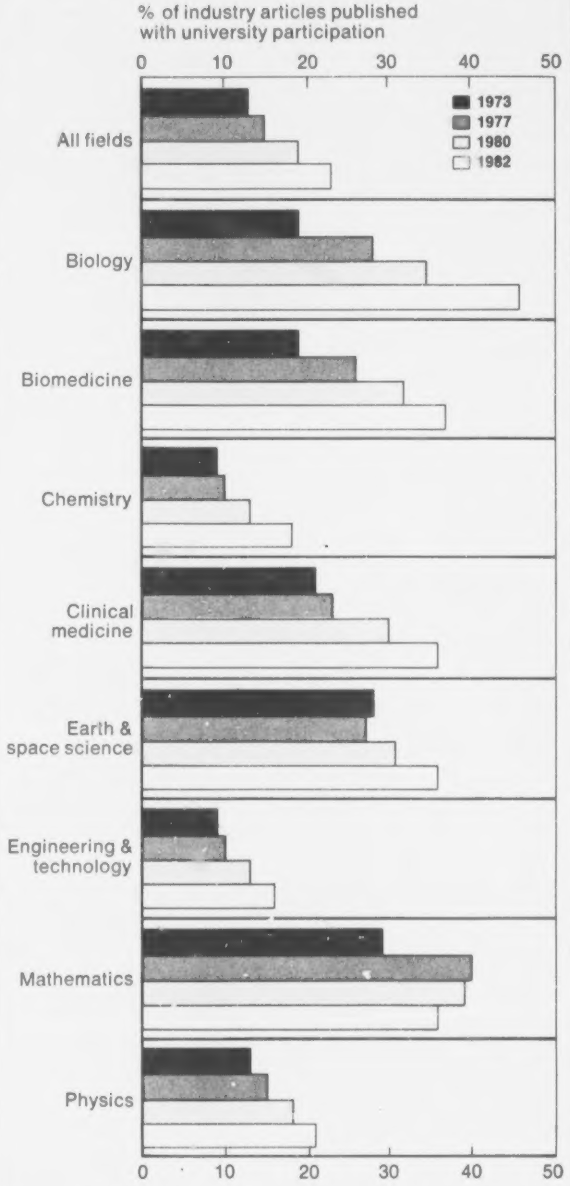
Bremer says the investigators and their universities must be extra watchful over the wording of contracts drawn up between the researcher and his department and the contracting company. "What people don't seem to realize even now," he says, "is that the knowledge being negotiated has been built upon 10 or 15 years of funding by others in any particular area. And the contracting companies simply seem to want to walk away with the fruits of all that research.

"Universities particularly have to watch where federal money is involved," he adds. "Most of the basic research in universities is still supported by the federal government, and so there's always the potential for the commingling of funds. It's obvious that the professor is being sought for his expertise that was gained across the funding spectrum."

Another aspect of the debate relates to technological change itself and its impact on labor and society, rising from the revolution in microelectronics, robotics, artificial intelligence, and computer-assisted manufacturing. The question is whether universities by their ties to corporations are directing technologies away from more humane directions. Inherent within that is a traditionally blue-collar distrust of big corporations.

The issue was legally underscored earlier this year when the California Rural Legal Assistance Agency sued the University of California, Davis, over the support of research on automatic harvesters that eliminated jobs of manual pickers. Was this a socially optimal technology? Weren't public universities also in the business of enhancing the employment system in the state? Wasn't the preservation of jobs an economic good? Was a public university reflecting only the values of the corporate ethic, which has always been to raise productivity?

The computer-assisted design and manufacturing revolution is illustrative. Again, corporations are funding universities to help them further develop fields of automatic control. Progress in the field is sure to eliminate jobs. Isn't it the obligation of universities to pursue parallel research in examining whether such developments are socially optimal? Must the productivity-conscious managerial mentality prevail? Is all progress defined as that which assures automatic control of systems? What is really wrong with labor-intensive technology? Might it not be more productive in the long run?



Industrial researchers increase collaborations with university counterparts

Source: National Science Foundation

"The claim that [computer-assisted design and manufacturing] increases productivity and competitiveness has not been proved or is at best ambiguous," says David Noble, curator of industrial automation at the Museum of American History in Washington, D.C., and associate professor of history of technology at Massachusetts Institute of Technology. "All it does do is reduce the direct labor costs, which are usually about 10% of the total manufacturing costs. In effect then, you are eliminating the blue-collar worker without necessarily increasing the output or unit costs." Noble, incidentally, is waging warfare against MIT for refusing to grant him tenure last year. He claims he was discriminated against by his outspoken disagreements with MIT research policies that he argues skewed technology away from public concerns. Another reason, Noble suggests, was the content of his new book, "Forces of Production—A Social History of Industrial Automation," in which he challenges conventional assumptions about automation and MIT's role in development of that technology.

The problem in the university, he says, is that "we are not allowed to pose the questions. To now, the questions relate only to the human interest rather than what we are going to do. We have to do more than just lament the plight of displaced workers. There's no compelling moral or rational reason preventing a moratorium on the introduction of new technologies, pending the solution of serious social problems. This would only be sound policy."

And Alden S. Bean, professor of management and technology at Lehigh University, says the university role may be to judge technology, but a more basic role is to train students to use it.

"My attitude is that the university is created so all the issues pertinent can be heard and debated," he says. "And the university should be rooted in its region and responsive to its constituencies. So nothing is all that conflicting. It must look at the broader set of long-term issues. We're not going to dismantle the [computer-assisted] technology nor is industry going to stop promoting it. And the students are not going to stop demanding educational opportunities. At the same time, the political science and labor economics faculty have to aggressively tackle the issues raised by the technology." Bean adds that there always has been structural unemployment during technological change in society.

Indeed, Robert Rosenzweig, president of the Association of American Universities, says the issue of faculty conflict of interest really needs a lot of attention. "The desire to attract more industrial research to the campus has created the need to understand the legal and ethical issues." As a start, AAU has established at the request of Congress a clearinghouse on corporate/academic ties to assess how different institutions are establishing working relationships with corporations and avoiding conflict of interest at the same time. A summary of the findings is due to reach Congress in October.

Rosenzweig has no problems with the general idea of industrial support for academic research. But he wants the rigid hand of regulation kept out of the system.

"I don't know how well most institutions are in control of these issues. There is greater sensitivity than there was three years ago. But I'm not sure how many universities want to make the effort to find out how individual faculty members are behaving. And on the whole I think they are right. If you go about the business of learning the way people behave you are under obligation to do something about it. And I'm not sure that the whole process wouldn't produce more trouble than it would be worth.

"These are issues that ought to be dealt with by exception—by violation of procedures and policies—than by any systematic enforcement."

Curiously, one important element of the country's system of higher education feels it is being left out: the private, high-quality liberal arts colleges that supply much of the talent to the graduate schools.

Oberlin president S. Frederick Starr, a historian, is heading a group of 35 such schools and has called for a fall meeting to be held at Oberlin to discuss "the future of the scientific enterprise in the small liberal arts college" in the face of what he sees as favoritism by the government and industry toward the research university. "One issue," Starr says, "would be the relationship that exists between the National Science Foundation and the research universities. To us, it seems that NSF's relationship to them is similar to the relationship that exists between the Pentagon and the arms producers." One would think, he says, that a college like Oberlin, which produces more than the average number of science students for the graduate schools, would be seen as a valuable resource by NSF and the corporations.

He also is disturbed by recent shifts downward in the proportion of corporate support for research at the undergraduate science level. "We get 17% less proportionately than we got five years ago," he says. He calls the drop an "alarming trend." "I would think U.S. industry would appreciate us as a resource and provide more direct support so as to preserve our strength."

It is difficult to arrive at any clear set of conclusions from this rapid and necessarily superficial excursion through a field of intense philosophical and economic debate. Biotechnology and computer-assisted design and manufacturing technology, along with all the other fields whose knowledge is for sale, represent individual, separate technical worlds. And yet in their intense energy to grow and transform society, they collectively challenge institutions of higher education to re-examine themselves.

Certainly, a case can be made that economic and industrial assistance (which is really what all these collaborations are about in the broader social scheme) fall within the range of the university's public service function. This is still a capitalist society, the form that is arguably most compatible with democracy. Still, people are concerned that universities will lose their critical functions at a time when that higher form of public service is perhaps needed most.

If universities forfeit honest social criticism to, say, journalism or television talk shows, they leave it in superficial hands. What does seem at stake is the teaching and practice of broad critical thought—an intellectual resource that many believe is under dire threat today when economic values of the marketplace appear to reign supreme. Universities might say they need the money, professors might say that work with industry broadens their usefulness to society and their students. But, the public citizen might still ask, at what cost? □

Upswing Continues in Demand for Thermoplastics

Rise in consumption, though at slower pace, begins to push limits of this year's available capacity for some major-volume plastics

Bruce F. Greek, C&EN Houston

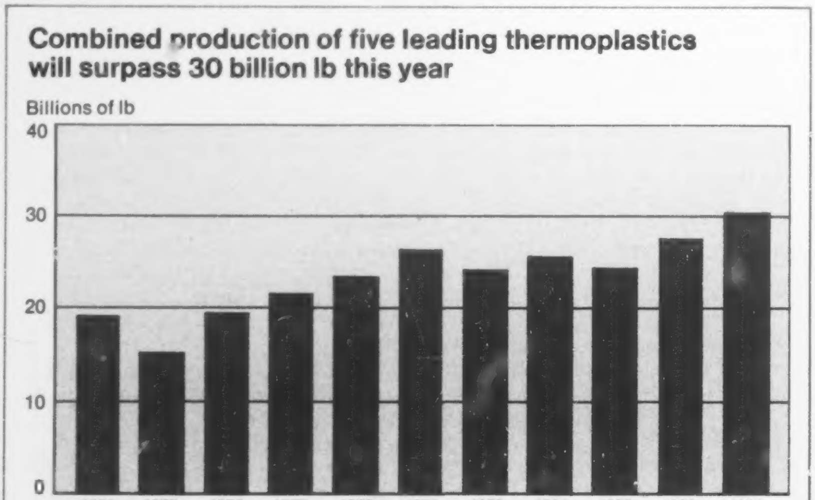
Producers of thermoplastics are happily riding a strong upswing in demand for their products. The vigorous rise in consumption that began last year carried over this year, although at a slightly slower pace. But it is continuing at a good enough rate that two of these thermoplastics, high-density polyethylene and polypropylene, will flirt with total utilization of the effective capacity to make them this year.

The other three major-volume thermoplastics—low-density polyethylene, polyvinyl chloride, and polystyrene—have varying degrees of overcapacity. Like polypropylene and HDPE, these plastics are experiencing sizable gains in production but have further to go to overcome the large buildup of capacities in the late 1970s and early 1980s.

Production for 1984 for these five major-volume thermoplastics is forecast to add some 2.3 billion lb to the 1983 total, bringing combined output to a record of more than 30 billion lb, representing an annual growth rate of about 8.3%. This gain is less than that in 1983, when recovery from the recession accelerated and production rose more than 14% from the depressed level of 1982.

Key Polymers

The dollar value this year will be up even more than production volume. Total value of 1984 production is expected to be up more than 40% from last year to nearly $12 billion. That would be 70% more than 1982's depressed level of less than $7 billion.


Combined production of five leading thermoplastics will surpass 30 billion lb this year

Sources: Society of the Plastics Industry's Committee on Resin Statistics, C&EN estimates

Clearly, profitability has improved for the five major thermoplastics. Part of the large value increase comes from substantial rises in list prices that began in 1983 and have continued into 1984. Even more important than higher list prices, actual selling prices also have improved substantially, with discounting considerably reduced this spring. Prices for the rest of 1984 are expected to hold at about current levels, subject to the usual pass-throughs of raw material cost changes.

Longer term, production values in this cyclical business are expected to continue to rise except for the dips caused by economic recessions. However, these rises may be considerably smaller than those of 1983 and 1984. Both production volume and actual selling prices probably will not rise so fast over the next five years as they rose in 1983 or are rising in 1984.

The reasons for slower gains involve the maturing of the big-volume thermoplastics. Marketers expect growth to be hindered by problems now developing. For instance, a decline in exports plus a possible rise in imports will require U.S. markets to absorb the additional volumes of products, and fewer markets of other materials such as glass, paper, or wood are left that plastics can capture.

Smaller growth rates than those of the 1970s are now widely accepted by all but the most determined optimists. Depending on the specific thermoplastic, the rates now forecast for the next five years are mainly in the 3 to 7% per-year range.

For details of the near-term outlook for these major thermoplastics, see the following pages.

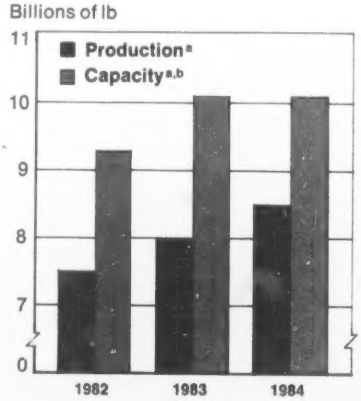
Key Polymers

$-\!\left[CH_2-CH_2 \right]\!-_n$

Low-density polyethylene

- ***Demand rising***
- ***Capacity on hold***
- ***Prices up***

PRODUCTION/CAPACITY



a Includes linear low-density polyethylene. b First quarter.

HOW MADE

Polymerization of ethylene (with comonomers as required by product needs) at high and low pressures aided by catalysts and initiators

MAJOR FABRICATED FORMS (U.S.)

Film (mainly for packaging) 65%, injection-molded items 10%

FOREIGN TRADE

Exports—may decline to below 750 million lb in 1984, imports—small, below 100 million lb in 1984

PRICES

List prices 38 to 43 cents a lb for large-volume grades, discounting lessening

COMMERCIAL VALUE

$3.4 billion for estimated production, 1984

Another fairly good year is under way for low-density polyethylene. Production, demand, and even profitability of producers will be better than they were in 1983. But to several industry sources, 1984 will not be so good as it could be.

Production of all forms of LDPE (that with densities of 0.94 or less) likely will total 8.5 billion lb in 1984. Placed on an annualized basis, production during the first quarter of this year ran just a bit below the 8.5 billion lb-a-year pace. However, these are preliminary data that often are revised upward.

According to a more optimistic scenario for 1984 low-density polyethylene production, the total for the year should amount to about 8.7 billion lb. This 8.7 billion lb total even allows for some of the usual slowdown in production during the third quarter.

Capacity for LDPE is more difficult to pin down than for other major-volume thermoplastics. An average estimate from a number of sources is that total capacity was a bit more than 10 billion lb at the beginning of the year. This figure causes considerable head-shaking among some sources because of the moves into linear low-density polyethylene by several companies by building new plants and converting some older high-pressure process technology plants, and also because of shutdowns of some of the old units that might yet be converted for making LLDPE. Probably if all installed capacity to make various forms of LDPE were counted, the total would be as much as 10 to 20% higher.

Obviously, economics determine the future of the shut-down older plants. Further conversion of these units to make LLDPE gets less likely as time goes by; rather, dismantling of these units becomes more likely.

Another topic subject to disagreement among marketing experts is that of the amount of LLDPE capacity that actually will produce high-density polyethylene this year. Although enough capacity exists to allow considerable HDPE to be made if desired, such activity will make the plant operating rate higher than it would be otherwise. Again, economics will determine what is made in these convertible units. Producers will run plants as necessary to fill sales needs with the result that any given producer could have a different product mix from the other producers.

Thus, any estimate of plant operating rate is necessarily more general for LDPE than for the other thermoplastics. Considering the range of production estimates, the operating rate may turn out to be 83 to 88%.

Strong arguments can be made for either end of that range. For instance, in favor of the high end are doubts about the highest estimates of available capacity, not to mention the possibility that demand might prove better than forecast later in the year as the continuous development of polymers better suited for specific uses aids sales. On the other hand, in support of the lower capacity use is the continuing problem of inventory-building in LDPE. Sales and captive use through the first quarter increased less than did production, according to the Society of the Plastics Industry's Committee on Resin Statistics. In March, sales were actually off a bit from March 1983, even though production in March 1984 was above the year-earlier month.

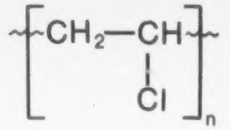
No important changes in the uses of LDPE appear to be in store that might affect production. Films continue to dominate uses at nearly two thirds of the total domestic consumption. The impact of LLDPE on the film uses of conventional low-density product seems to be lessening as blends of the two types of polyethylene get wider use.

Exports of LDPE now look as if they will be down about 150 million lb in 1984 from their 1983 total. Behind this decline will be the continuing strength of the dollar, as it hits all exports, and increasing capacity to make polyethylene in other parts of the world by companies, some of which are government-owned or -dominated, that must sell production at whatever price they can get.

Thus, U.S. producers of LDPE will have to work hard to achieve a gain in volume this year equal to that of last year. This will be especially difficult since some of the U.S. demand will be filled by product that otherwise would have been exported.

Key Polymers

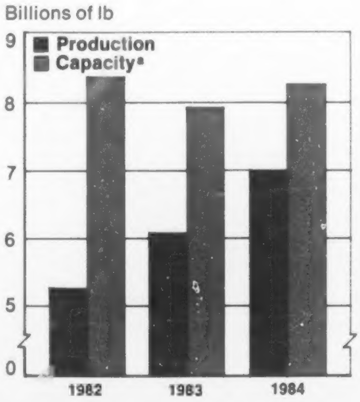
Polyvinyl chloride



$$\sim\left[\mathrm{CH_2{-}\underset{\displaystyle Cl}{\underset{|}{CH}}}\right]_n\sim$$

- ***Demand well up***
- ***Capacity to rise***
- ***Prices stronger***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Polymerization of vinyl chloride by suspension, emulsion, bulk, or solution processes initiated by free radicals

MAJOR FABRICATED FORMS (U.S.)

Extrusions, nearly two thirds of which are pipe, 65%; calendered sheet and film 10%; molded items 5%

FOREIGN TRADE

Exports—falling to about 450 million lb in 1984, imports—rising rapidly and may exceed 200 million lb in 1984

PRICES

List prices 37 to 45 cents a lb for large-volume grades, discounting less than last year

COMMERCIAL VALUE

$2.5 billion for estimated production, 1984

A banner year is in store for polyvinyl chloride. Vastly improved 1983 production and nearly as good growth in 1984 are expected to go a long way to offset the three bad years of 1980 through 1982.

Production of PVC could hit 7 billion lb in 1984, up 900 million lb from 1983. And since 1983 production was up 800 million lb from 5.3 billion produced the year before, the health of the PVC business seems well recovered in these two years. Production in 1982 was the lowest since 1977, when the same amount was made. The 1983 production matched the previous high in 1979.

Further aiding the health of the PVC industry has been a shakeout of producers and capacity. Nameplate capacity, at one time well over 9 billion lb a year, declined steeply with the last recession and then moved back up. As 1984 began, annual nameplate capacity to make all kinds of PVC totaled about 8.3 billion lb. Some additional capacity is coming on stream during 1984, both as complete production unit additions and as the result of debottlenecking efforts by various producers. By the beginning of 1985, PVC capacity could be up to 8.8 billion lb. Other capacity, long shut-down, might be reactivated and add to the total, but most industry sources doubt if much of this capacity will ever be touched again because of the technological advances that favor building new units over using old units.

If output in 1984 does reach 7 billion lb, then on-stream capacity will have to run at an average rate of nearly 85%. The actual average rate probably will not be quite this good because of additional capacity that will be run during the latter part of 1984.

The 7 billion lb figure for 1984 production, as always, represents a middle ground between optimists' and pessimists' views. The range among market forecasters falls about 300 million lb on either side, from 6.7 billion to 7.3 billion lb.

Optimists cite the strong first quarter in both production and sales of PVC to support their forecasts' topping 7 billion lb. Sales in the quarter, according to data of the Society of the Plastics Industry's Committee on Resin Statistics, exceeded production more than 125 million lb. This inventory reduction, in effect, means that production will have to be increased later to cover the inventory reduction unless demand should slip quite drastically.

The key to most pessimists' arguments comes from forecasts of higher interest rates and reduced housing starts. If interest rates should rise one or two percentage points during the summer, housing starts could decline substantially this fall, according to most economists. This would reduce demand for PVC in pipe, fittings, floor materials, and the various other components of the housing market. Then an inventory reduction could begin in the fourth quarter, reducing demand and, in turn, production to offset the good first half of 1984.

Clearly, both viewpoints rely on the housing markets for PVC forecasts. This is because housing takes about two thirds of PVC production, either in the form of new construction or in repairs and refurbishing. Interest rates influence both areas of housing, too. Since the home owner generally will require a loan for big-ticket improvement items such as fast-growing vinyl siding, interest rates will have some effect on the nonpipe as well as pipe markets.

Pipe of one kind or another accounts for about 40% of PVC consumption. More than half of pipe goes into housing, with commercial construction taking much of the rest. Probably 10% or less of pipe goes into such nonconstruction uses as irrigation.

The nonpipe segment of PVC consumption is spread over a wide range of consumer products, none of which are large enough to affect total demand. Examples are phonograph records, which have grown little in recent years, and bottles, which eventually might grow significantly if bottle-making developments pan out.

Work on developing new uses for PVC and improving existing uses likely will be expanding now that production has returned to new highs, aiding profitability in making and selling PVC. If the work proves successful, then more good years are in store giving new life to this somewhat mature thermoplastic.

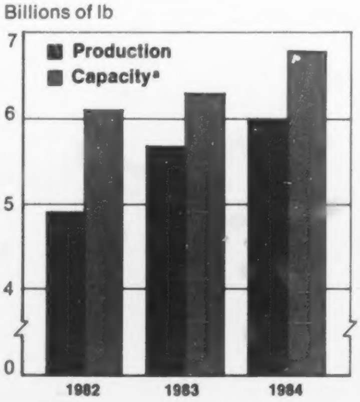
Key Polymers

$-\!\!\left[CH_2-CH_2 \right]\!\!-_n$

High-density polyethylene

- ***Demand rise slowing***
- ***Capacity up slightly***
- ***Prices better***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Polymerization of ethylene at low pressures aided by metallic salts and alkyls

MAJOR FABRICATED FORMS (U.S.)

Blow-molded items, mainly containers, 40%; injection-molded items 25%; pipe and conduit 10%

FOREIGN TRADE

Exports—expected to be down substantially to 800 million lb in 1984, imports—small, probably will total less than 50 million lb in 1984

PRICES

List prices 38 to 45 cents a lb for large-volume grades, much less discounting last year

COMMERCIAL VALUE

$2.4 billion for estimated production, 1984

High-density polyethylene will continue to have one of the best plant utilization levels of all chemicals in the U.S. But that level this year or any other year will be hazy.

On the surface, capacity use should be quite high during 1984. Production of HDPE this year will be about 6 billion lb, maybe even more. Estimates of plant capacity range from more than 6 billion lb to well over 9 billion lb, the big difference resulting from the amount of linear low-density polyethylene capacity that could be used to make HDPE. Therefore, capacity utilization could range downward from nearly 90% of nameplate capacity—which is 100% of effective capacity—if the LLDPE swing is not counted, to less than 70% of nameplate capacity if it is.

Demand for LLDPE has continued to be surprisingly strong, even as the economic recovery has slowed. Thus, demand for the low-density product could be the controlling factor in the amount of HDPE made in those plants that have swing capacity available.

Any of this swing capacity—estimated at 3.5 million lb—that might be dedicated exclusively to HDPE likely would be small, according to industry sources. All additional capacity that has been put on stream lately—such as Du Pont's new plant near Bay City, Tex., and expansions at existing plants by such companies as Allied and Gulf Oil—is dedicated to produce only HDPE. And even though more expansions are rumored from time to time, the potential of shifting the swing LLDPE capacity tends to dampen such rumors.

With a nameplate total capacity of plants that can make only HDPE of about 6.8 billion lb as the year began, making 6 billion lb in 1984 will require producers to push their plants at an average operating rate of 88%. Some industry sources forecast that 1984 production will be higher than 6 billion lb but believe that capacity will not be strained. Some slack still exists in capacity and perhaps some 100 million to 200 million lb of production could come from the LLDPE plants.

The rate of production growth during 1984 will be just one third that of 1983, as recovery from the recession last year helped HDPE almost as much as any major-volume polymer. However, the demand gain in the U.S. will be greater than the production gain. A decline in exports of more than 150 million lb expected in 1984 will have to be absorbed by U.S. markets. New capacity in foreign countries and the strength of the dollar are behind the expected decline in exports.

The use pattern for HDPE may change slowly as smaller applications such as pipe, film, and sheet grow faster than the big molding uses do. The pipe market covers several kinds of products but is split about half and half between solid-wall and corrugated pipe. A shift is under way toward larger-diameter pipe and thicker-walled pipe, which raises the resin consumption.

The key to the future of film markets for HDPE now seems to be the grocery bag market. Extensive development continues on these bags aimed at overcoming the problem that such bags will not stand up alone or stay open without some kind of holder. The use of other merchandise bags made of HDPE alone or of blends of HDPE and LLDPE is wide and still growing rapidly.

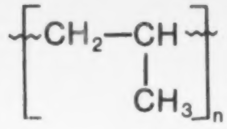
Bottles of various types dominate the blow-molding demand for HDPE, with 1-gal milk bottles taking 80% or more of the food market for such containers. Efforts to replace coated paper in the half-gallon market are handicapped by the usual problem of the cost of the higher polymer-to-bottle volume ratio than for 1-gal bottles. There is also a huge public relations campaign by the makers of paper milk containers to stop inroads of plastic bottles into the market.

Injection molding of HDPE faces some growing competition from polypropylene resins. But the diversity of present and potential uses causes some people to forecast faster growth for injection molding than blow molding.

For HDPE, 1984 will be a test of how well development efforts can sustain consumption growth in the U.S. to absorb the loss of export volume. Even with a slowdown in the economy, HDPE consumption likely will add as much as 9% to 1983 consumption and bring production over 6 billion lb for the year.

Key Polymers

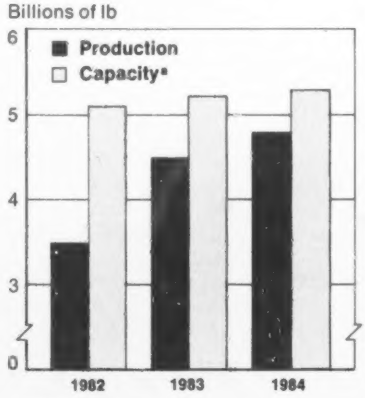
Polypropylene



$$\left[-CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}-\right]_n$$

- ***Demand growth to slow***
- ***Capacity up a bit***
- ***Prices improved***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Polymerization of propylene (sometimes with small amounts of comonomers) aided by metallic salts and alkyls

MAJOR FABRICATED FORMS (U.S.)

Injection-molded items 35%, fibers and filaments 35%, film 10%

FOREIGN TRADE

Exports—may decline in 1984 to about 750 million lb, imports—about 10 million lb in 1984

PRICES

List prices 40 to 47 cents a lb for large-volume grades of homopolymers, discounting reduced

COMMERCIAL VALUE

$2.0 billion for estimated production, 1984

Technological change is sweeping through the ranks of polypropylene producers. Although it may not have much impact on demand this year, it could lead to some large changes next year and through the rest of the 1980s.

The change, in the form of gas-phase processing with more active polymerization catalysts, apparently has cut processing costs substantially. The result could be greater cost competitiveness for polypropylene and increased demand beyond forecasts that have been made based on historical prices. But partly offsetting the technological gains in reducing polymer cost has been a shift from the traditional ratio of propylene costing 70% or so of the raw material ethylene; now propylene and ethylene prices are much closer together.

Polypropylene's upward swing in production will abate somewhat during 1984, marketers say. In a fashion similar to other major-volume thermoplastics, the big recovery in production during 1983 will slow, resulting in a 1984 growth rate of about a third the gain last year. Output likely will reach 4.8 billion lb this year, but could go as high as 5 billion lb. First-quarter production of 1.23 billion lb—the figure released by the Society of the Plastics Industry's Committee on Resin Statistics—indicates that production could get quite close to the 5 billion lb-a-year level. However, sales are not so large as production, suggesting that inventory-building has been going on during the quarter and that production might slow later in the year, especially during the third quarter as fabricators shut down for vacations, maintenance, and product line changes.

If production does slow, and the yearly total turns out to be 4.8 billion lb, then existing capacity will be run at an average rate of 90% for the year.

About 200 million lb of polypropylene capacity will be added this year, mainly through debottlenecking of existing units by the use of more efficient catalysts. Some of these expansions—for example, one at Exxon Chemical—are coming on stream gradually. Then, in 1985, another 200 million lb of capacity is expected from the joint venture of Shell Chemical and Union Carbide. The partnership is converting an old high-pressure-process LDPE unit at Seadrift, Tex., to its new low-pressure polypropylene process.

Even if inventory-building is accounting for quite a bit of the production gain so far in 1984, the question of lost sales because of a lack of capacity to supply demand still arises. Generally, marketing experts contacted by C&EN say that loss of sales will be minor in 1984 if the economic recovery is slowing. Next year additional capacity plus the decline in exports would handle demand.

Inventories of polypropylene fabricated items also may have increased rapidly during 1983 and may be overhanging the market now. The thinking behind the product inventory building comes from the large increase in polypropylene production during 1983 of about 1 billion lb. This production gain surprised most market forecasters. The highest gain forecast last year was about 500 million lb, with most forecasts at about 300 million lb. Hence the jump of about a billion pounds sent marketers on a search for where the unexpected production had gone.

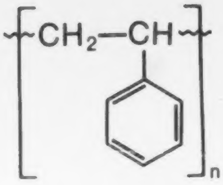
Fibers, which run a close second to injection molding as a major form of polypropylene fabrication, now seem to get the nod for where the downstream inventory was built up most rapidly. How serious the inventory of fibers and filaments is to this year's polypropylene growth projections apparently depends on the economy and, in particular, housing. Housing is the most important fiber end use.

The major fabricated end use for polypropylene is in the many injection-molded items ranging from appliance parts to battery cases. Some of these are a part of the durables market and the high-priced products that consumers are buying again. A good bit of the remainder is packaging and other short-lived items. These items likely will bolster polypropylene demand this year as long as the economy stays healthy.

After coming off a year of a very large gain in production, polypropylene likely will be catching its breath in 1984 with just a small gain in output. Later, as the impact of technological developments appears, a new big round of capacity building may be in store for this key polymer.

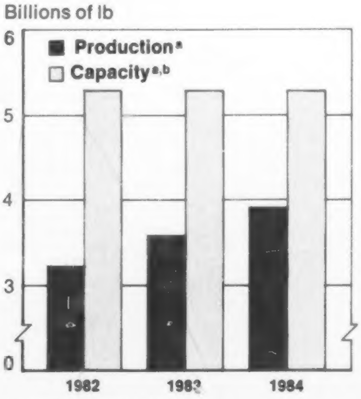
Key Polymers

Polystyrene



- ***Demand growth slower***
- ***Capacity on hold***
- ***Prices up some***

PRODUCTION/CAPACITY



a All forms. b First quarter.

HOW MADE

Polymerization of styrene using initiators

MAJOR FABRICATED FORMS (U.S.)

Injection-molded items 40%, extruded items 35%, expandable beads 15%

FOREIGN TRADE

Exports—small, holding at 50 million to 100 million lb in 1984, imports—about 10 million lb in 1984

PRICES

List prices 42 to 48 cents a lb for large-volume grades, discounting lessening

COMMERCIAL VALUE

$1.6 billion for estimated production, 1984

Polystyrene producers are looking for some developments that will add sparkle to their business. Several prospects, such as expandable polystyrene beads and audio and video cartridges, reels, and cases, have appeared on the horizon but none have turned out to be the real incentive to growth needed. As a result, polystyrene is headed again for another year of only modest growth.

Production of polystyrene in 1984 could be up 300 million lb, or 8%, from 1983 to 3.9 billion lb. That still would be below the historical high for polystyrene production of just over 4 billion lb in 1979. Some industry sources, however, feel that production this year will not be up more than 5% because of a slowing in the economy.

Capacity to make polystyrene has been on hold for some time—hovering at about 5.3 billion lb. The overcapacity created has been putting pressure on prices for some time, too, a euphemism, according to one source, that means profits have been none or meager. Depending on the estimates of 1984 polystyrene production, the in-place capacity at the beginning of the year will be run at an average rate of 70 to 74%. As has been the case in recent years, this operating rate will be the lowest among the major-volume thermoplastics.

In spite of the seemingly chronic overcapacity, some expansions are coming along, even as part of the existing capacity remains shut down. Gulf Oil, for example, soon will be completing an expansion of its Marietta, Ohio, plant that will add 130 million lb per year there. Other debottlenecking expansions could bring another 200 million lb of additional capacity by the beginning of 1985.

How much capacity will be scrapped is difficult to estimate. Production technology has become relatively simple, making retention of older plants a bit easier to justify. These long-shut-down plants could be restarted five years later, according to some industry observers, and still be reasonably competitive. But if growth in polystyrene doesn't speed up, it could be the end of the decade before all capacity now in place would be needed.

Demand growth for polystyrene seems always to be blunted by one kind of competing development or another. For example, producers at one time said expandable polystyrene beads pull up demand for polystyrene strongly. But during the recent recession, demand for these beads remained flat. Admittedly, this is better than a decline, which occurred for most other major uses of polystyrene, but still it has been a disappointment to producers. Now, beads may be back on the high-growth trail, but their outlook depends strongly on the insulation market, which, in turn, depends on home building. In 1984, producers hope that demand for beads will break away from the holding pattern of about 450 million lb annually, a level first reached in 1979. The relatively high selling price of beads—15 to 20 cents per lb more than for conventional polystyrenes—may have attracted too many producers to this segment of the business and has caused considerable overcapacity.

In other areas of use, polystyrene continuously feels the pressure of other polymers such as relative newcomer polypropylene. Although various developments are helping, polystyrene often is replaced by other polymers because of its brittleness.

Injection-molded components of audio and video cartridges could push polystyrene to higher growth. Some sources view these cartridges as major potential markets because of the sales growth in home video cassette recorders (VCR). With a pound or more of polystyrene in each cartridge case and reels, volumes now are forecast in the 100 million to 200 million lb-a-year range for home VCR cartridges alone. Additional quantities are needed for commercial cartridges and for the smaller-volume application in audio cassettes.

Polystyrene demand might be helped by developments such as performance-impact polystyrene for uses where even higher impact resistance is needed, and by various upgraded rubber-modified polystyrenes aimed at some of the acrylonitrile-butadiene-styrene polymers' markets. As yet, these products are used in small volume. However, it will take a long time before these developmental products add much to total polystyrene demand.

U.S., Canada Weigh Possibility of Petrochemical Free Trade

Canada has initiated duty-free trade proposal and U.S. government is receptive, but U.S. industry has adopted wait-and-see attitude

Earl V. Anderson, C&EN New York

Like Lazarus of biblical fame, the idea of freer, if not completely free, trade between the U.S. and Canada has been raised from the dead. In both countries, influential political and business leaders are now solidly in favor of negotiating duty-free trade in several industrial sectors.

If the idea becomes a reality—and there is an excellent chance that it will—petrochemicals will be in the forefront of the strongest assault toward bilateral free trade between the two countries since they signed the duty-free automotive trade agreement in 1965.

Certainly chemical industry leaders on both sides of the border are taking the possibility very seriously. Already, two lengthy meetings on the subject have been held between the Chemical Manufacturers Association and its Canadian counterpart, the Canadian Chemical Producers Association (CCPA).

Officials of both organizations emphasize that their meetings were only preliminary and exploratory. "They absolutely were not negotiations," says one official; "only governments can negotiate." Nevertheless, CCPA has produced a "preliminary" list of 26 petrochemicals on which it would like to see two-way, duty-free trade between Canada and the U.S.

This list very well could be accepted by the Canadian government as a starting point for sectoral trade negotiations in petrochemicals if and when such negotiations get under way. And it's amost certain that, if petrochemical trade talks do take place, that list will be peppered with proposals to remove some products and to add others.

So far, negotiations haven't been scheduled. But optimism that they will be held never has been higher.

One reason for that optimism is that this time Canada initiated the proposal for sectoral free trade. Last fall, Ottawa issued a major report outlining a new approach to Canadian trade policies for the 1980s. And, in a major policy switch, it recommended sectoral free trade with the U.S. for selected industries.

No longer is there so much worry about too much dependence on U.S. markets. Instead, the concern is how to retain, and even increase, market share in the U.S. As one Canadian businessman put it, "Ottawa has made a virtue out of necessity."

Despite these changing attitudes in Canada, a completely free trade arrangement with the U.S., such as a free trade area or a customs union, still would be hard to sell north of the border. But duty-free trade limited to some specific industrial sectors could be more palatable.

The Canadian initiative has received a warm welcome among U.S. trade officials. William Brock, the U.S. Trade Representative, has had several talks about sectoral free trade with Canada's minister of international trade, Gerald Regan.

As a result of these meetings, four sectors now are "under active consideration" by the Canadian and U.S. governments. These four sectors are agricultural equipment and inputs (which may include agricultural chemicals), steel (both carbon steel and specialty steel), computer services, and government procurement of mass transit equipment.

These four are considered the priority sectors, presumably because officials anticipate fewer problems negotiating free trade with them than with other sectors. And officials on both sides want to start off with successes, not failures.

Later, of course, other industrial sectors can be added to the sectoral free trade agenda. Petrochemicals rank high among them. The petrochemical industry was listed in Canada's original policy statement endorsing sectoral free trade. In fact, petrochemicals have been candidates for some form of liberalized trade between the two countries for some time.

Immediately after the Tokyo round of multilateral trade negotiations in the late 1970s, proposals for duty-

26 products proposed for duty-free trade

Styrene
Cyclohexane
Ethylbenzene
Carbon tetrachloride
Ethylene dichloride
Vinyl chloride
Propanol
Methanol
Ethylene oxide
Ethylene glycol
Phenol
Acetic anhydride
Acetic acid
Adipic acid
Hexamethylenediamine
Acrylonitrile
Alkylbenzene
Polyethylene
Polyvinyl chloride
Polystyrene
Vinyl acetate
Styrene-butadiene latex
Acetaldehyde
Adiponitrile
Nylon 6
Nylon 66

Canada is a major supplier of many U.S. chemical imports

$ Millions	U.S. chemical imports: Canada	Total	% Canada
Organic chemicals	$517.5	$3476.6	14.9%
Benzene	47.1	206.1	22.9
Toluene	55.8	99.6	56.0
Xylene, nec	48.2	57.0	84.6
Styrene	8.6	25.4	33.9
Cyclic organics, nec	35.1	571.8	6.1
Vanillin	12.2	14.5	84.1
Butadiene, butylene, ethylene, propylene	130.9	345.3	37.9
Perchloroethylene	3.9	8.0	48.8
Halogenated hydrocarbons, nec	18.7	65.1	28.7
Ethanol (nonbeverage)	13.0	102.0	12.8
Octanol	14.6	21.4	68.2
Ethylene glycol	4.6	9.8	46.9
Alcohols, esters, ethers, nec	57.8	139.6	41.4
Ethylene oxide	2.6	2.7	96.3
Propylene oxide	13.2	13.2	100.0
Nitrogenous compounds, nec	7.7	383.9	2.0
Inorganic chemicals	559.4	1615.8	34.6
Sulfur	62.5	129.1	48.4
Chlorine	20.7	20.7	100.0
Carbon black	11.3	17.1	66.1
Chemical elements & base metals, nec	15.4	18.8	81.9
Sulfuric acid	7.8	11.7	66.7
Hydrofluoric acid	31.5	79.1	39.8
Zinc oxide (not containing lead)	15.6	26.4	59.1
Titanium dioxide	27.4	167.7	16.3
Ammonia, anhydrous, liquid anhydrous & aqua	111.4	344.6	32.3
Aluminum oxide abrasives, crude	52.7	53.7	98.1
Sodium hydroxide	41.3	61.1	67.6
Nickel oxide	12.7	19.1	66.5
Calcium cyanide & silicon carbide	34.7	39.7	87.4
Sodium chlorate	35.0	35.2	99.4
Sodium sulfate, crude	7.6	9.8	77.6
Sodium sulfate, anhydrous	14.5	17.5	82.9
Inorganics, nec	10.8	157.1	6.9
Radioactive & associated materials	201.2	951.7	21.1
Dyeing, tanning & coloring materials	2.0	299.5	0.7
Pigments, paints & varnishes	19.0	145.5	13.1
Medicinals & pharmaceuticals	28.2	702.6	4.0
Flavors, perfumes, cosmetics & toiletries	18.6	370.2	5.0
Cleaning & polishing materials	18.7	90.3	20.8
Fertilizers, manufactured	740.2	997.2	74.2
Ammonium nitrate, all forms	52.6	60.9	86.4
Urea	112.1	235.9	47.5
Ammonium sulfate, all forms	18.0	24.1	74.7
Nitrogen solutions	12.5	23.9	52.3
Potassium chloride (or muriate of potash)	485.1	547.8	88.6
Diammonium phosphate	6.8	9.3	73.1
Ammonium phosphates, nec	22.7	26.4	86.0
Fertilizer materials, nec	25.7	28.1	91.5
Explosives and pyrotechnics	19.9	64.5	31.3
Plastics and resins	184.1	1097.6	16.8
Low-density polyethylene	11.6	29.2	39.7
High-density polyethylene	6.6	12.7	52.0
Polypropylene	0.8	5.1	15.7
Rubber, synthetic	4.2	19.6	21.4
ABS	4.2	24.2	17.4
PVC	26.6	53.7	49.5
Synthetic resins & plastic materials in primary form, nec	18.1	120.0	15.1
Plastics products	98.0	594.2	16.5
Pesticides & disinfectants	10.3	251.2	4.0
Miscellaneous chemical products	60.6	716.8	8.5

nec = not elsewhere classified. Source: U.S. Bureau of the Census

free shipment of Canadian petrochemicals to the U.S. began to surface. Most of the proposals came out of Alberta where a fledgling world-scale petrochemical industry was taking shape. Canadian petrochemical industry representatives suggested duty-free entrance for about a dozen Canadian petrochemicals, all of them "commodity" type products and most of them first or second ethylene derivatives. In exchange, the U.S. would receive favorable treatment on Canadian natural gas exports.

This proposal died along with other proposals made at about the same time for some form of North American trade alliance encompassing the U.S., Canada, and Mexico (C&EN, July 14, 1980, page 12). But it resurfaced in the Canadian government's trade policy statement last year and again this year in a task force report on petrochemicals that industry prepared for Ottawa.

It should not be surprising that chemicals in general, and petrochemicals in particular, should be considered for special trade treatment. A lot of chemical trade takes place between the two countries. And a lot of this trade already is duty-free.

That trade represents a greater proportion of the total for Canada than it does for the U.S. For instance, last year Canada exported $2.4 billion in chemicals to the U.S. and imported $2.5 billion from it (U.S. data). For Canada those figures mean 65% of total chemical exports and a hefty 78% of total chemical imports.

Canada's share of U.S. chemical trade isn't that overpowering, but it isn't small change, either. Last year, Canada took 12% of all U.S. chemical exports and provided 22% of all its chemical imports.

For some petrochemicals, free trade already exists between Canada and the U.S. For instance, fertilizer materials such as ammonia and urea move duty-free. Tariffs have been negotiated away on such primary petrochemicals as benzene, toluene, xylene, ethylene, propylene, and butylene. Canada exports large volumes of these products to the U.S.

However, tariffs still exist on

many first- and second-generation derivatives. And it is toward eliminating these tariffs that CCPA's list of 26 is aimed. But that list and the meetings between CCPA and CMA are only the first step along a long road to successful government negotiations in petrochemical free trade. Nobody in either the U.S. or Canadian petrochemical industries expects that list to survive the trip intact.

In the U.S., most of the industry work concerning sectoral free trade with Canada is concentrated in CMA and the Office of the Chemical Industry Trade Adviser (OCITA). Right now, however, most of that effort involves collecting information and disseminating it to OCITA and CMA members.

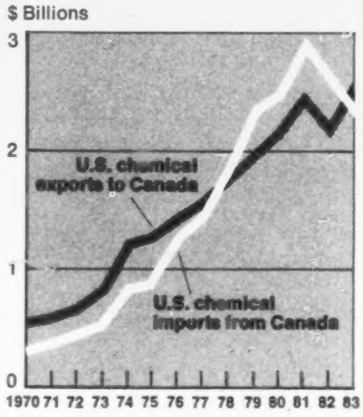
Myron T. Foveaux, CMA's assistant director of government relations and a leading industry trade expert, says that CMA can do only so much for its members on this issue. At the moment, CCPA's proposal is relatively simple—have two-way, duty-free trade on the products on its list.

But if balanced benefits are to be achieved within each sector, achieving it with this narrowly defined list could prove difficult, if not impossible. When the Canadian government presents the list to the U.S. negotiators, U.S. chemical companies will be waiting in line to make their own counterproposals, striking some chemicals from the CCPA list and adding others.

Don't expect a counter list from CMA, however. CMA, says Foveaux, is in no position to offer lists of products. First, it doesn't represent the entire chemical industry. And what it might propose to help one member could end up harming another. "We want no part of that," says Foveaux.

The opportunity for U.S. companies to make their own suggestions will come when the federal government holds its own investigations. Typically in such cases, these could include hearings before the International Trade Commission and/or the Trade Policy Staff Committee, a high-powered interagency group chaired by USTR. Industry input also could funnel into the trade representative's office through the industry sector advisory committee that handles chemicals.

U.S. chemical trade with Canada returns to surplus



Source: U.S. Bureau of the Census

The outcome of such a process could be an industry-suggested list that would look quite a bit different from CCPA's list. Depending upon how "petrochemicals" are defined—and that hasn't been pinpointed yet—a list more to the appetite of some U.S. companies could go further toward downstream products than Canadian chemical leaders care to go.

Rolland G. Frakes, senior vice president, Novacor Chemicals, Calgary, and chairman of CCPA's trade committee, says that he and his Canadian cohorts recognize that there will be some deletions and additions to the CCPA list. But they would like to keep future negotiations confined as much as possible to basic petrochemicals, without too many upgraded products involved. "We're not as far out of balance in petrochemicals as many think," says Frakes.

He thinks that the next step should be for "real professionals" to make a thorough economic evaluation of the proposals. But that may have to wait until the two governments give industry experts a target to shoot at.

It is hard to say when that might happen, on the U.S. side at least. Petrochemicals still are "under consideration" by the U.S. trade representative's office. But, as William S. Merkin, deputy assistant U.S. trade representative for the Americas, points out, there are four joint working groups working on the four priority sectors, and that does not represent a commitment to negotiate.

The petrochemical sector has no working group yet, and one would not even be considered until the two countries' top trade officials meet again this fall. But there are hints that the U.S. trade office may not wait until then to at least get ITC involved in an economic impact analysis.

Meanwhile, there remains the problem of reconciling any sectoral free trade arrangement with the international trade treaty already in effect, the General Agreement on Tariffs & Trade, or GATT. Under GATT rules, such agreements should cover essentially all trade.

"We haven't resolved this issue yet," says Merkin. There really are only two ways to go, he says. One is a GATT article that provides for free trade areas; the other is to seek a waiver as the two countries did for the automotive agreement in 1965.

The waiver was granted in 1965. Things are different now. Other trading partners may not be in any mood to grant waivers.

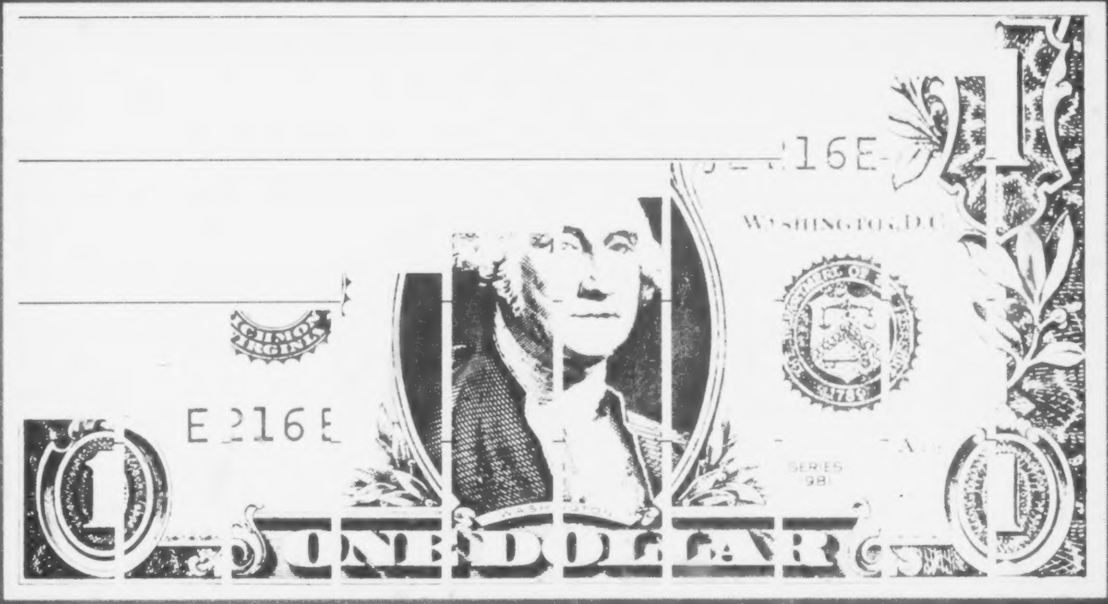
Merkin notes, however, that of the 40 or so free trade arrangements reported to GATT, none really encompass total free trade. Most are in the 50 to 60% range; some go as low as 10%. Certainly any sectoral free trade arrangements reached by Canada and the U.S., on top of the large volume of duty-free trade that already exists, could qualify under GATT by those standards.

Despite the problems involved, chemical trade experts in the U.S. and Canada seem confident that some sort of sectoral trade arrangement will be completed for petrochemicals. CMA's Foveaux notes that "this is the farthest it has gone so far."

CCPA's Frakes says that a free trade agreement should fly because both sides are concerned about the influx of new producers onto the world petrochemical scene. "We should be looking at what it would be like if North America were one chemical market instead of two," he says. ☐

JULY 2, 1984

CHEMICAL & ENGINEERING NEWS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SALARY SURVEY

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CHEMICAL & ENGINEERING
NEWS

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JULY 2, 1984

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- **GE develops low-cost process to make electronic printed circuit boards.** **Page 5**
- **Genes responsible for heart-derived peptides that play a part in blood pressure control have been cloned for research studies.** **Page 5**
- **Encouraging women to pursue careers in chemistry is the goal of a five-college consortium.** **Page 6**
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Biotechnology Stocks Still Floundering

Some securities analysts, weighing a variety of technical factors and a growing feeling that institutional investors, heavy with cash at the moment, are about ready to start buying stocks again, now are predicting a summer stock rally. Would a general surge sweep along the shares of biotechnology-based companies? Most of them would like to think so.

Biotechnology stocks have taken a severe beating since reaching their last peak early in the year. Between Jan. 6 and June 15, Standard & Poor's 400 Industrials stock index declined 11%. During the same period, C&EN's biotechnology stock index plunged 24%, more than twice the drop of the market in general. C&EN's biotechnology stock index—based on a fairly arbitrary selection of companies—tracks share prices of Amgen, Applied Biosystems, Biogen, Centocor, Cetus, Damon Biotech, Genentech, Genetic Systems, Genex, Hybritech, Molecular Genetics, and Monoclonal Antibodies.

The decline of the C&EN biotechnology stock index also was worse than that for the Over-the-Counter Composite Index—18% between Jan. 6 and June 15 of this year. Other major measures of stock market performance also indicated large declines, but most were of much smaller dimensions than that of the biotechnology stocks. For instance, the Dow Jones Industrials Average went down 16% during the period; the Dow Jones 65 Stocks Average declined 18%; the New York Stock Exchange Composite dropped 12%; the New York Stock Exchange Industrials dropped 11%; and the American Stock Exchange Index dropped 13%.

The biotechnology stock decline was general. Of the dozen companies, only the shares of Applied Biosystems, a supplier of lab equipment to biotechnology-based companies, rose in price—up 5.3% since the beginning of the year.

Of the 11 losers, least battered were the two biggest companies: the price of shares of Genentech, which made several major scientific breakthroughs but failed to get a product on the market in the first half of the year, dropped 11%, and the price of shares of Cetus, which last month formed a $60 million partnership with W. R. Grace & Co. (C&EN, June 18, page 8), declined 14%.

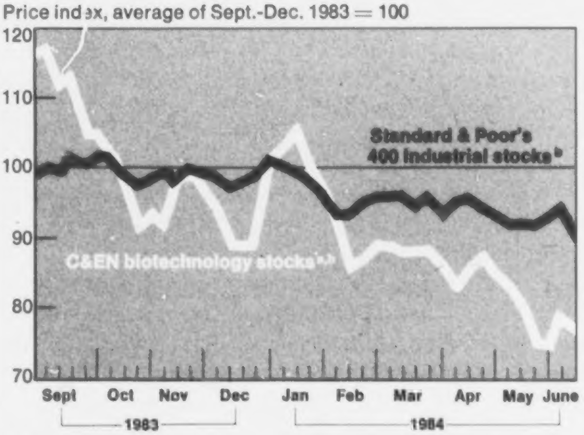
Stock prices of the other firms decreased far more sharply. Monoclonal Antibodies, rapidly increasing revenues from its diagnostic kits, still declined 20%; Molecular Genetics, now selling its first product in the U.S., still went down 23%. Biogen stock was down 24%, Damon Biotech 28%, Hybritech 31%, Amgen 33%, and Centocor 37%.

The two worst performers were Genex, the price of whose stock was down 44%, and Genetic Systems, whose stock was down 45% since Jan. 6.

As a result, most biotechnology stocks are trading at prices near the low end of their 52-week range. Applied Biosystems, again, is an exception. Whether some of these stocks are now poised to begin rising again remains to be seen.

David Webber, New York

Biotechnology stock prices have fallen further than rest of the market . . .



a Based on stock prices for Amgen, Applied Biosystems, Biogen, Centocor, Cetus, Damon Biotech, Genentech, Genetic Systems, Genex, Hybritech, Molecular Genetics, and Monoclonal Antibodies. b Reindexed to average for Sept.-Dec. 1983 period to show relative change.

. . . and many stocks remain near bottom of last 12 months' range

Company	Recent price[a]	52-week range	
		High	Low
Amgen	$ 5⅜	$18	$ 4⅝
Applied Biosystems	20	22½	2¼
Biogen	8½	17¾	8
Bio-Response	8¾	16⅛	8
Bio-Technology General[b]	6½	10	5
California Biotech	7	14	7
Centocor	9½	19¼	8¾
Cetus	11¼	17⅞	10
Collaborative Research	5¼	15½	4¼
Damon Biotech	6⅝	17½	6
Enzo Biochem[b]	15¼	34¼	12¼
Genentech	34	49¾	25⅞
Genetic Systems	5¾	17¾	5⅝
Genex	9	23¼	8¼
Hybritech	14¾	30¾	12¼
Molecular Genetics	10¼	22½	8¾
Monoclonal Antibodies	11½	21½	10

a As of Friday, June 15, close. b Adjusted for split.

Conference mulls Europe's specialties prospects

Whether Western Europe's chemical climate is conducive to building profits by entering the specialties business was scrutinized late last month by nearly 200 delegates attending a specialties conference in Monte Carlo.

It was a session forcing them to ponder that for Europe specialties account for only about 18% of total chemical industry sales, whereas in the U.S. they are just shy of a quarter of chemical sales. It also was a session that took on the color of a primer course in specialties acquisition with 10 speakers from acquisition- or business-strategy consultant firms and one securities analyst concerned with acquisition impact on share prices.

And it was a session carrying warnings from at least one consultant, Charles H. Kline, president of Charles H. Kline & Co., of Fairfield, N.J., that the current emphasis in the U.S. is on specialty materials—for example, fiber composites—rather than specialties per se. The time for chemical specialties, he suggested, already may have passed.

Nonetheless, interest in specialties continues high, as Adolf Lanzdorf, a principal with consultants Booz Allen & Hamilton in Düsseldorf, West Germany, and Nigel Andrews, a vice president at that company's New York City headquarters, pointed out in a joint presentation. Companies recognize that international specialty market positions are important, they said, in such fields as pharmaceuticals, adhesives, and biotechnology. Moreover, commodity companies recognize that on the whole, specialties are faster growing and more profitable than commodity lines, so are entering such fields both to capture such advantages and to make themselves more attractive as stock market investments.

Acquisitions are a good way to enter the chemical specialties business, Kline says, but such acquisitions are becoming increasingly expensive, so companies opting to get into the business this way must be increasingly selective.

In addition, companies also handicap themselves with unrealistic acquisition criteria, according to Lanzdorf and Andrews. For high returns, competitive position in a market, rather than the attractiveness of the market segment itself, is important, and profitability within segments can vary up to 7% from the average. A large part of the market is already controlled by a few major companies, both in Europe and the U.S., with few independent companies of significance existing. Therefore, acquisition criteria that specify 10% annual growth, a leading position in the market, an attractive market, and so on, lead to only 3% of acquisition targets being acceptable.

Specialties are only 18% of chemical sales in Europe

$ Billions	Europe	U.S.	Other	Total
Specialties	$ 27	$ 34	$ 19	$ 80
Fine chemicals	22	20	13	55
Pseudo-commodities	65	53	50	168
Commodities	40	36	38	114
TOTAL	$154	$143	$120	$417

Source: Charles H. Kline & Co.

Andrews suggests that companies contemplating entering the specialties field seek opportunities in what he terms discontinuities in the business, in applications expertise and substitution economics. These could involve opportunities arising from patent expiration (for example, photoresists), technical substitution (such as biotechnology), customer preference changes (for instance, water treatment), system economics (advanced materials and agricultural chemical intermediates), and new applications for existing technology (such as fluorination in agrochemicals).

Whatever field a company enters, however, there are several possible routes for buying into the business. Frode Nordhoy, president of Consultant Strategic Analysis of Reading, Pa., outlined the ways to enter. A company could acquire the leading supplier in a business, Nordhoy points out, which would give a solid market position, but at a premium price. It could acquire a minor supplier, to give a "window" into the market, but it would then be difficult to expand significantly. A company could acquire several smaller suppliers, to avoid the high premium, but it would find it difficult and slower absorbing the several purchases than just one large one. Or it could purchase technology, or enter a joint venture, he adds.

On the other hand, a company can always elect to develop specialties in-house. However, this can be difficult, because most corporate management in the chemical industry has grown up thinking "bulk" commodities and markets. And even a small, halfway step toward bridging the gap between commodities and specialties can be fraught with problems.

That was the report of J. A. Bigot, director of planning and development for the chemical products division at DSM, the Netherlands state-owned oil and petrochemicals producer. His testimony was vivid evidence that "specialties" is relative; DSM includes as such many products that others consider too large-volume to be true specialties. But it can be a first step toward higher-value specialties for a large oil producer geared to bulk chemicals.

According to Bigot, when his fine chemicals group first started and its activities were a negligible element in the overall business of the company, its planning—highly flexible and action oriented—was basically ignored or treated condescendingly by the rest of the company. However, as the group grew and gradually began asking for more resources, pressure was put on the group to take part in the planning system developed for the bulk operations—with much data gathering and long-term, inflexible predictions. "It took permanent and strong opposition" to avoid being put under those constraints, Bigot reported, as his group fought to justify its existence. And later, in the question-and-answer session, he added that the group although profitable and growing, still must fight to justify its existence; there are still bumps in the road. ☐

Although Unemployment Dips This Year, Salary Gains Are Slim

Median salaries are 5% higher than last year for Ph.D. chemists but up only 3% for non-Ph.D.s, survey of ACS members indicates

Like the financial health of the U.S. chemical industry, the economic status of U.S. chemists has improved this year from what it was in 1983. Unemployment is lower. Salaries are up.

But so far as the job situation goes, this year's figures look more favorable when compared with the previous year's than with those from earlier years. The latest annual survey of the economic status of American Chemical Society members indicates that 1.7% of the chemists were jobless and looking for employment, as of last March. Although down from the 10-year peak of 2.2% a year earlier—and far below the overall U.S. unemployment rate of 7.7% of the labor force that month—that unemployment rate for chemists is higher than in any previous year since 1976. And it is appreciably higher than the approximately 1% level of joblessness that prevailed from 1979 to 1981.

Moreover, 93.7% of ACS chemists (excluding those who are unemployed but not seeking work) were working full time this past March. Although that's a slightly higher percentage than the year before, it is lower than in any earlier year since 1972, when unemployment climbed to 3.2%. Much of the decline in unemployment, in fact, can be attributed to an increase in the number of chemists holding down postdoctoral or fellowship positions; nearly 3% of ACS chemists are doing such work, a higher fraction than at any time in the past decade.

This year's survey, conducted by the ACS Office of Statistical Services under the aegis of the Council Committee on Economic Status, also indicates that chemists' salaries rose only modestly during the 12 months ending last March—even less than had been the case during the two previous years. For Ph.D. chemists, the median salary increased 5% to $42,000. (The median is the salary that is exceeded by 50% of all individuals responding to the ACS survey.) Not since 1978 had the year-to-year gain been so slim. And for chemists whose highest degree is either a B.S. or an M.S., annual salaries (excluding earnings from overtime or supplemental employment) at the median were only 3% higher than indicated by the 1983 survey. That's only half the average annual increase during the past 10 years.

Few ACS members, no matter what their background, are looking for work this year . . .

	Chemists										
		By sex		By highest degree			By minority status		Chemical engineers	All members[c]
Employment status[a]	Total	Men	Women	B.S.	M.S.	Ph.D.	Minority[b]	Nonminority		
Employed full time	92.9%	93.7%	87.7%	94.3%	93.9%	91.9%	87.7%	93.2%	93.4%	92.7%
Employed part time	1.7	1.3	4.2	1.7	2.1	1.5	0.8	1.8	1.6	1.8
Postdoctoral or fellowship	2.9	2.8	3.5	0.5	0.3	4.9	8.3	2.4	0.7	2.5
Unemployed										
Seeking employment	1.7	1.6	2.6	2.2	2.2	1.2	3.2	1.6	3.0	1.9
Not seeking employment	0.9	0.7	1.9	1.3	1.5	0.5	0.0	0.9	1.3	1.0

a As of March 1, 1984. **b** Black, American Indian, Alaskan native, Asian, Pacific Islander, Filipino, Hispanic, or other. **c** Includes ACS members whose highest degree and present work are in neither chemistry nor chemical engineering. **Source:** ACS survey

. . . and salaries have risen less than is usual for the past decade

											Annual change		
$ Thousands	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1983–84	1979–84	1974–84
CHEMISTS' MEDIAN SALARIES[a]														
B.S.	$30.9	$30.0	$28.5	$27.5	$25.0	$23.5	$22.0	$21.0	$19.8	$19.0	$17.5	3%	6%	6%
M.S.	34.0	33.0	31.6	30.0	26.0	25.0	24.0	22.0	20.5	19.8	18.4	3	6	6
Ph.D.	42.0	40.0	37.5	35.0	31.2	29.0	27.4	26.0	24.7	23.0	21.7	5	8	7
All chemists	38.0	36.0	34.7	32.0	28.9	na	na	na	na	na	na	6	7[b]	na

a As of March 1, 1984. **b** Annual change for the years 1980–84. **na** = not available. **Source:** ACS survey

Salaries increase with experience, but less markedly 30 years or more after graduation

Years since B.S. degree	Annual salaries of nonacademic chemists ($ thousands)[a]										
	0 to 1	2 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 or more	Overall
B.S.											
90%	$26.0	$30.0	$35.0	$44.8	$51.4	$54.8	$62.3	$63.4	$70.0	$87.6	$52.0
75%	23.8	26.0	30.0	38.0	41.6	47.0	55.0	52.5	50.4	60.0	40.8
50%	20.2	23.0	26.0	32.5	36.5	38.6	42.5	45.0	40.0	47.0	31.0
25%	17.0	20.0	22.9	27.0	30.9	32.5	35.0	36.1	33.6	35.0	24.4
10%	14.4	16.8	20.0	23.0	25.3	27.0	29.4	30.0	27.4	28.0	20.0
M.S.											
90%	—	33.6	36.0	45.0	54.2	60.0	58.2	71.6	71.4	79.0	56.0
75%	—	28.0	32.9	39.1	45.0	50.0	49.5	60.0	57.1	51.7	45.2
50%	—	25.9	28.8	33.4	39.0	43.0	43.0	45.0	48.0	46.0	36.0
25%	—	23.0	25.0	29.0	32.6	34.0	36.2	37.0	40.6	38.6	30.0
10%	—	20.0	21.5	25.9	28.0	27.7	29.0	32.0	30.3	25.4	25.0
Ph.D.											
90%	—	—	42.0	49.8	60.0	71.3	70.0	78.3	80.2	81.6	68.0
75%	—	—	38.7	45.0	52.0	60.0	60.4	65.0	68.0	69.0	56.0
50%	—	—	36.0	40.0	45.0	50.0	52.0	55.0	55.6	59.0	46.0
25%	—	—	33.6	36.3	39.0	43.0	45.0	45.0	47.4	49.5	39.0
10%	—	—	31.0	33.6	34.4	37.3	39.0	38.5	38.2	40.4	34.0

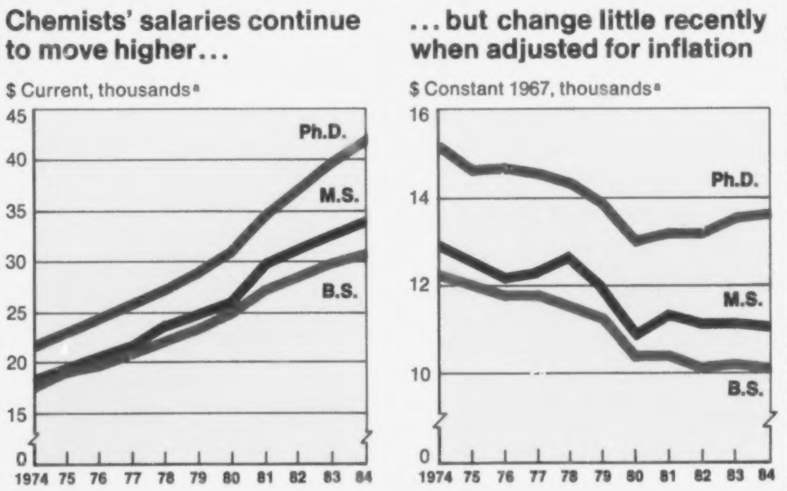
[a] As of March 1, 1984. **How to read this table:** Using, as an example, B.S. chemists two to four years after having received their B.S. degree, 90% of these chemists have annual salaries of $30,000 or less, 75% have annual salaries of $26,000 or less, 50% have annual salaries of $23,000 or less, 25% have annual salaries of $20,000 or less, and 10% have annual salaries of $16,800 or less, as of March 1, 1984. **Source:** ACS survey

This year's moderate improvement in median salaries, however, at least is roughly in line with price inflation during the past year or so. Consumer prices increased a little less than 5% between March 1983 and March 1984. During the past four or five years, by and large, salaries for chemists were nearly unchanged, after adjustment for inflation. For Ph.D.s, in fact, salaries measured in constant dollars actually have edged up a bit since 1980. This recent record at least compares favorably with the severe slump in the purchasing power of chemists' salaries that took place during the seven years beginning with 1973. Nevertheless, constant-dollar salaries this year still are about 10 to 15% lower than they were a decade ago.

For individual chemists, however, whatever degree they have, the overall median provides scant information regarding the way their salaries stack up against those of colleagues. Typically, chemists working in industry earn more than those employed elsewhere. Those who supervise several people do better than those who supervise few or none. In industry, as would be expected, chemists in managerial jobs earn appreciably more than those who work in research labs or in production assignments; those in marketing positions fall between these groups. For industrial chemists, too, salaries tend to be highest for the 6% who work for petroleum firms.

Among academic chemists, those teaching at schools that offer a Ph.D. degree have a strong salary advantage over their colleagues employed by colleges or universities that do not. This is especially true for those who are full professors.

No matter where chemists work, experience is one of the most significant factors affecting their salaries. It is considerably more a factor during the first 20 years or so after earning a degree, however, than in the latter stages of a career. Thus, for nonacademic chemists with a B.S. degree, the median for those who graduated 20 to 24 years ago is nearly double the median for those who have started working only in the past year. But the median for nonacademic B.S. chemists with 40 or more years' experience is only about a fifth higher than for those who are 20 to 24 years out of school.



[a] Median salary of chemists as of March of each year. **Source:** ACS survey

Industrial chemists earn most working for petroleum firms

Industry	% of industrial chemists All chemists	B.S.	M.S.	Ph.D.	Mean salary ($ thousands)[a] B.S.	M.S.	Ph.D.
Chemical	34%	29%	31%	39%	$36.9	$39.6	$46.2
Pharmaceutical[b]	18	16	19	18	35.3	37.8	50.9
Petroleum	6	5	5	7	40.6	46.1	55.1
Coatings	5	7	6	3	34.5	40.1	47.3
Food	4	4	4	4	34.7	37.5	47.8
Metals and minerals	3	4	3	2	34.2	37.5	45.5
Rubber	2	3	3	2	34.9	40.4	49.5
Other manufacturing	21	22	22	21	34.7	39.0	48.6
Nonmanufacturing	7	10	8	5	33.0	47.4	48.7

[a] As of March 1, 1984; to facilitate comparison, salaries are adjusted for differences in the average experience for each group. [b] Includes personal care products. **Source:** ACS survey

Salaries rise as number of subordinates increases

Number of subordinates	Median annual salaries,[a] chemists in private industry ($ thousands) All chemists	B.S.	M.S.	Ph.D.
ALL SUBORDINATES				
0	$33.5	$27.8	$32.0	$41.0
1-2	40.0	32.7	37.3	44.0
3-7	42.0	35.0	39.1	47.4
8-12	49.6	40.0	45.5	53.5
13-17	51.0	43.8	47.5	55.0
18-22	52.5	45.0	48.4	57.6
23-32	57.8	46.0	50.0	65.0
33-47	64.0	48.0	52.8	69.0
48-67	64.5	56.0	—	66.3
68-99	79.0	—	—	79.2
100 or more	80.0	75.0	65.8	88.5
PROFESSIONALS AND TECHNICIANS ONLY				
0	$33.8	$28.0	$32.0	$41.0
1-2	40.0	33.0	37.0	43.7
3-7	43.0	36.0	40.0	48.0
8-12	50.0	42.0	47.4	54.5
13-17	52.0	49.0	50.0	53.6
18-22	53.5	45.0	44.5	59.0
23-32	65.0	57.5	57.1	65.0
33-47	65.0	52.8	57.0	67.5
48-67	66.3	64.0	62.8	70.0
68-99	80.0	—	—	80.0
100 or more	86.0	—	—	88.0

[a] As of March 1, 1984. **Source:** ACS survey

Similarly, for Ph.D. chemists working outside of academia, the difference between median salaries of those with about 20 years of work experience and those with four years or less is roughly double the difference between those with 20 years' experience and those who are 36 or more years away from obtaining their Ph.D.

As for academic chemists, median salaries advance sharply as individuals rise through the ranks from assistant to associate to full professor (as most of them apparently do). But the differences in medians with length of experience once full professorship has been attained are much less distinct.

Academic chemists, however, no matter what their rank or experience, earn salaries well under those of their industrial counterparts. Compare, for example, salaries of Ph.D. chemists who received their B.S. degree 25 to 29 years ago. The median for those working at basic research in an industrial lab is 25% higher than those employed as a full professor in a Ph.D.-granting college or university and 60% higher than those ranked as associate professors. For industrial chemists who are managing R&D, the median salary at this level of experience is 36% higher than that for full professors in Ph.D.-granting institutions.

The differences in salary with experience, type of employer, and work function that are indicated in this year's survey of ACS members are similar to those found in previous ACS surveys. As in the past, too, men tend to earn higher salaries than women, wherever they work. In part, this reflects the fact that women, as a group, are younger and less experienced than men in the overall ACS sample. For example, among chemists working in industrial jobs, two thirds of the women finished undergraduate school less than 15 years ago, but only slightly more than a third of the men did so.

But even if the data are adjusted for differences in years of experience for men compared to women, the salary advantage for men persists. The gap between men's and women's salaries, moreover, does not seem to have narrowed appreciably in recent years. For B.S. chemists in industry, in fact, it has widened; this year the mean (rather than median) salary for women was just under 80% that for men. Last year, for women with a B.S. who were employed as industrial chemists, the mean salary was 85% that of similar men; in 1982, it was 88% as high.

On the other hand, among industrial chemists with a Ph.D. degree, the mean salary for women is 92% that of men, up from 86% in 1983 but down from 96% in 1982. For academic Ph.D.s, however, the adjusted mean salary for women is 82% that

Women's salaries are most comparable to men's for Ph.D. chemists

Mean salary, $ thousands[a]	B.S. All chemists	Men	Women	Women as % of men	M.S. All chemists	Men	Women	Women as % of men	Ph.D. All chemists	Men	Women	Women as % of men
EMPLOYER												
Private industry	$36.4	$36.9	$29.2	79%	$40.4	$41.2	$35.1	85%	$50.2	$50.4	$46.1	92%
College/university	—	—	—	—	30.2	31.0	25.6	83	33.7	37.5	30.8	82
Government	31.3	32.0	29.2	91	34.5	35.9	27.8	77	44.2	44.7	41.0	92
Other	29.6	30.1	29.3	97	36.1	37.9	29.9	79	44.8	46.4	34.9	75

[a] As of March 1, 1984; to facilitate comparison, salaries are adjusted for differences in the average experience for each group. **Source:** ACS survey

In industry, women earn less than men and researchers' salaries lag those of managers

Years since B.S. degree		Median salary ($ thousands)[a]										
		0–1	2–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40	Overall
CHEMISTS EMPLOYED FULL TIME IN INDUSTRY												
Sex												
Men	B.S.	$21.4	$23.7	$27.8	$33.3	$38.0	$40.0	$44.5	$45.2	$40.4	$46.5	$34.0
	M.S.	—	25.5	30.0	35.0	39.1	48.0	44.2	48.3	47.0	45.0	38.0
	Ph.D.	—	—	36.4	41.5	46.5	52.5	55.0	56.0	60.0	58.0	48.0
Women	B.S.	20.6	23.0	25.0	27.6	35.5	32.6	(36.0)	40.0	(40.0)	—	25.5
	M.S.	—	(26.7)	27.8	30.0	37.2	(34.0)	(38.0)	(38.8)	—	—	30.2
	Ph.D.	—	—	35.7	38.0	42.0	(40.0)	—	(55.0)	—	—	38.6
Work function												
General management	B.S.	—	—	(28.4)	(36.0)	(40.0)	(46.0)	(58.0)	52.5	61.3	(61.5)	46.7
	M.S.	—	—	(29.8)	(33.6)	(48.0)	—	—	(69.5)	(54.0)	—	50.0
	Ph.D.	—	—	—	(45.0)	50.0	55.9	(67.0)	74.0	(60.0)	(78.0)	60.0
R&D management	B.S.	—	—	(31.1)	40.0	41.3	(44.0)	54.0	48.5	45.0	58.0	45.5
	M.S.	—	—	(35.0)	40.2	45.0	55.0	(50.0)	58.6	54.2	—	48.0
	Ph.D.	—	—	(38.7)	45.6	53.0	58.0	60.0	61.2	66.0	64.0	58.0
Basic research	B.S.	21.0	23.2	26.4	29.2	(35.5)	(36.5)	—	(42.0)	—	—	26.0
	M.S.	—	(25.5)	28.8	33.0	36.0	(42.2)	(42.9)	—	—	—	34.0
	Ph.D.	—	—	36.4	40.0	42.9	55.0	55.0	55.9	55.6	(60.0)	42.0
Applied research	B.S.	21.1	23.6	26.6	30.4	35.2	38.6	41.4	45.5	41.0	42.5	30.0
	M.S.	—	(26.0)	30.0	35.0	36.0	37.7	43.0	41.9	42.1	(46.4)	35.0
	Ph.D.	—	—	36.0	40.0	43.3	48.0	51.0	51.0	54.2	53.0	43.7
Marketing[b]	B.S.	—	24.0	33.0	33.4	(40.0)	40.0	45.0	47.0	41.0	(50.0)	40.0
	M.S.	—	—	31.3	(41.0)	(45.1)	(53.8)	—	47.5	(54.0)	—	42.7
	Ph.D.	—	—	(36.0)	—	(45.0)	(57.0)	(62.0)	(55.0)	—	(58.0)	50.8
Production[c]	B.S.	20.0	22.4	26.8	33.0	35.4	36.0	37.8	37.6	36.0	(29.5)	28.8
	M.S.	—	(26.7)	27.0	33.5	36.0	(45.0)	41.5	(35.5)	(47.5)	—	34.2
	Ph.D.	—	—	(37.5)	(40.0)	43.7	44.0	(49.0)	(43.1)	(45.0)	—	42.5
Work specialty[d]												
Analytical chemistry	B.S.	20.5	22.9	25.8	33.0	36.0	36.0	40.0	45.0	35.0	40.0	30.0
	M.S.	—	(25.0)	29.4	33.0	38.0	44.2	(43.0)	41.0	(46.8)	—	34.0
	Ph.D.	—	—	35.4	41.2	45.0	49.5	51.5	51.0	55.0	(50.0)	44.0
Agricultural chemistry	B.S.	—	(21.8)	(24.0)	(35.0)	(40.1)	—	(36.0)	(39.6)	(60.0)	—	35.0
	M.S.	—	—	—	35.3	—	—	—	(47.5)	—	—	38.0
	Ph.D.	—	—	(36.2)	39.0	50.6	50.0	(53.1)	(56.0)	(62.4)	(56.4)	48.0
Biochemistry	B.S.	—	(20.0)	(36.0)	—	—	—	—	—	—	—	22.0
	M.S.	—	—	—	—	(32.6)	—	—	—	—	—	33.5
	Ph.D.	—	—	(35.5)	41.7	44.2	(50.0)	(56.0)	(53.0)	(63.1)	—	44.2
Environmental chemistry	B.S.	—	(23.8)	26.5	33.8	(40.0)	—	—	(40.0)	(54.6)	—	32.2
	M.S.	—	—	28.2	32.6	(36.0)	(33.0)	(36.0)	—	—	—	33.5
	Ph.D.	—	—	—	(40.0)	(43.0)	61.0	(54.0)	(62.3)	—	(56.5)	51.0
Inorganic chemistry	B.S.	—	(25.2)	(26.0)	—	—	—	(45.0)	(43.9)	—	—	39.0
	M.S.	—	—	—	(37.0)	—	(45.5)	—	—	—	—	40.5
	Ph.D.	—	—	36.7	42.8	45.0	50.0	(50.6)	58.0	—	—	46.0
Organic chemistry	B.S.	(21.0)	25.0	27.5	28.0	38.0	38.6	52.0	45.0	(46.3)	59.6	36.0
	M.S.	—	—	27.1	33.4	40.0	50.0	(44.0)	47.5	50.0	—	40.5
	Ph.D.	—	—	36.0	40.0	46.5	52.0	55.0	52.5	54.0	56.5	48.0
Pharmaceutical chemistry	B.S.	(21.7)	22.5	25.6	30.0	40.0	(48.5)	—	(50.2)	(40.0)	—	22.9
	M.S.	—	(26.2)	26.8	33.2	38.9	—	—	(54.4)	—	—	35.2
	Ph.D.	—	—	36.0	40.5	45.0	57.5	56.1	59.0	(69.5)	65.5	47.0
Physical chemistry	B.S.	—	(23.5)	(35.0)	(32.1)	—	—	—	—	—	—	35.0
	M.S.	—	—	(30.0)	—	—	—	—	—	—	—	38.0
	Ph.D.	—	—	39.0	44.0	49.0	53.0	54.0	60.0	(69.2)	(80.0)	48.5
Polymer chemistry	B.S.	(24.5)	24.0	29.0	32.8	37.5	42.4	(45.2)	50.0	(44.9)	(56.0)	35.0
	M.S.	—	(28.0)	31.3	40.1	41.2	48.0	44.2	49.0	(45.8)	(40.0)	40.0
	Ph.D.	—	—	37.5	40.0	47.5	52.5	56.0	60.0	60.0	61.0	49.4
CHEMISTS EMPLOYED FULL TIME IN ACADEMIA (Ph.D.s ONLY)												
Ph.D.-granting schools												
Professor		—	—	—	—	39.2	40.0	44.0	49.0	50.0	53.5	47.5
Associate professor		—	—	—	31.0	34.8	34.6	34.0	(36.5)	(37.7)	(35.0)	33.7
Assistant professor		—	—	24.0	26.2	27.4	30.0	—	—	—	—	26.0
Non-Ph.D.-granting schools												
Professor		—	—	—	—	32.5	32.0	34.6	36.0	36.0	32.4	34.2
Associate professor		—	—	—	25.0	25.0	27.5	30.0	30.0	(30.0)	—	26.8
Assistant professor		—	—	19.8	21.0	22.1	(21.2)	(22.6)	—	—	—	21.0

a As of March 1, 1984. **b** Includes purchasing, technical service, and economic evaluation. **c** Includes quality control. **d** Refers to current work, not field in which degree was obtained. **Note:** Where no salary data are shown, sample is too small to provide a meaningful figure; data in parentheses are from relatively small samples as well and should be treated with caution. **Source:** ACS survey

Unemployment is lower than last year for chemists, but still higher than in earlier years

Employment status[a]	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Employed full time	93.7%	93.5%	94.9%	95.6%	95.9%	95.0%	95.7%	95.4%	94.7%	95.0%	95.1%
Employed part time	1.7	1.7	1.4	1.1	1.0	2.0	1.0	1.1	1.3	1.3	1.0
Postdoctoral or fellowship	2.9	2.6	2.2	2.2	2.2	1.9	1.9	2.1	2.2	2.0	2.5
Unemployed	1.7	2.2	1.5	1.1	0.9	1.1	1.4	1.5	1.9	1.6	1.4

a As of March 1; excludes unemployed chemists not seeking employment. **Source:** ACS survey

for men; last year it was 84% and in 1982 it was 89%.

The gap between men's and women's salaries is narrowest during the early years of their career. The median for women in industry with a B.S. is 97% that for men if they have been working for only four years or less. But women industrial chemists who received a B.S. 20 to 24 years ago have a median salary only 82% as high as that earned by similar men.

As has long been the case, women also are more often unemployed than men. This year's ACS survey indicates that 2.6% of women chemists last March were without jobs but seeking them, compared with only 1.6% of men chemists. The 1984 unemployment rate for women, nonetheless, is lower than the rates of 3.3% in 1983 and 2.8% in 1982. Women also are more likely than men to be working part time, doing postdoctoral work, or out of the job market.

Unemployment likewise is nearly twice as high for chemists who do not have a Ph.D. degree than for those who do. For B.S. chemists, the unemployment rate has declined to 2.2% from 3.3% in 1983; for Ph.D.s it has fallen to 1.2% from 1.8% last year. The rate for chemists whose highest degree is an M.S., however, is essentially unchanged from 1983 at 2.2%.

The employment picture is likely to brighten further for chemists this year. Business continues to improve for the chemical industry and other business areas that employ large numbers of chemists. Production in the chemicals and allied products industry is nearly 20% higher now than it was at the recession low in late 1982. And profits for major U.S. chemical producers surged 70% from a year earlier during this year's first quarter.

Joblessness is least in government and academia

	% of chemists in category	% unemployed[a]
MOST RECENT EMPLOYER		
Industry	57%	1.8%
College/university	28	1.3
Government	9	0.3
Other	6	2.1
MOST RECENT WORK FUNCTION		
R&D[b]	35%	1.4%
Teaching	27	1.3
Management[c]	16	1.4
Marketing, production[d]	12	2.1
Other	10	1.9
MOST RECENT WORK SPECIALTY		
Analytical	21%	2.1%
Organic	17	1.5
Polymers	11	1.4
Pharmaceutical	9	1.5
Biochemistry	8	0.8
Physical	8	1.5
Inorganic	7	2.0
Environmental	6	2.0
Agricultural	4	1.3
Other	8	2.3

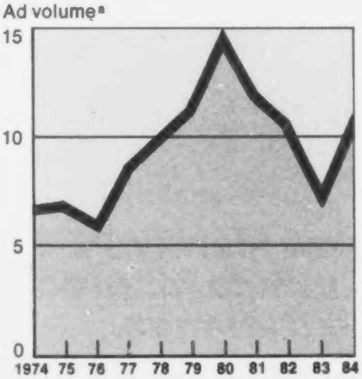
a As of March 1, 1984; excludes unemployed chemists not seeking employment. b Nonacademic only. c Includes R&D management. d Includes purchasing, technical service, economic evaluation, and quality control. **Source:** ACS survey

Unemployment highest among youngest chemists

Age	% of chemists in category	% unemployed[a]
20–24	2%	4.8%
25–29	12	2.1
30–34	17	1.6
35–39	15	1.3
40–44	14	1.1
45–49	11	1.9
50–54	10	0.9
55–59	9	2.6
60 and older	9	1.7

a As of March 1, 1984; excludes unemployed chemists not seeking employment. **Source:** ACS survey

Help-wanted ads rebound from three-year slump



a Volume of help-wanted advertising (in thousands of column inches) in C&EN for the 12 months ending with May of each year.

Growing strength in the job market for chemists is clearly indicated by the rising volume of classified employment advertising running in C&EN, which carries more such advertising for chemists than any other U.S. publication. So far this year, the volume of help-wanted advertising is about two thirds higher than a year ago. Volume for 1984's second quarter alone was 77% higher than in the second quarter of 1983, climbing to the highest level for any second quarter since 1980.

The data on the current employment status and salaries of ACS members reported here are based on more than 10,000 responses to a survey conducted last March by the Office of Statistical Services of the ACS Department of Professional Services. The survey was limited to members who are not older than 70, have U.S. mailing addresses, and do not have student, retired, or emeritus status.

Later this month, the Office of Statistical Services will publish a report on its annual survey for 1984 with a more detailed compilation of data than presented above. This report, "Salaries 1984," can be purchased from the Distribution Office, American Chemical Society, 1155—16th St., N.W., Washington, D.C. 20036, for $75 a copy. ☐

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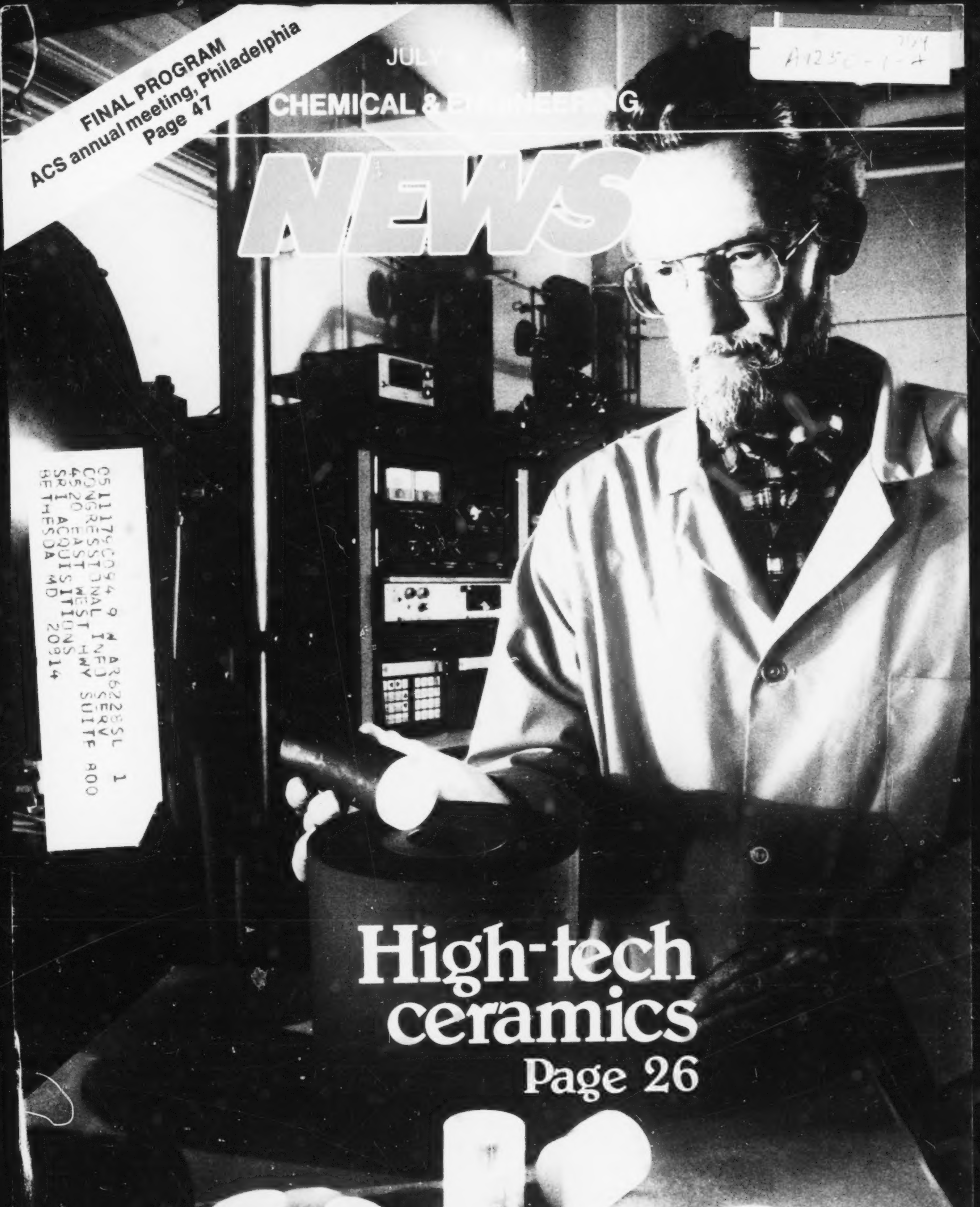
NEWS



FINAL PROGRAM
ACS annual meeting, Philadelphia
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High-tech ceramics

Page 26

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CHEMICAL & ENGINEERING NEWS

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JULY 9, 1984

News of the Week

- **Industry funding of academic research is not harmful to academic values if guidelines are followed, task force says.** **Page 6**
- **Senate bill would provide almost $900 million over two years to improve math and science education in public schools.** **Page 7**
- **Employment of scientists and engineers in the 1970s increased 4% per year, NSF finds.** **Page 7**

Business

Uniroyal's goal is to be a chemical producer; it will use its tire business to generate funds for expansion, acquisition. **Page 11**

International Business

Bulging capacity puts European makers of zeolites on lookout for new catalyst applications as well as renewed growth. **Page 14**

Government

Senate committee draft of TSCA revisions requires more toxicity tests for chemicals list of those presumed hazardous. **Page 18**

Technology

Experts at conference on fire toxicity disagree on identity of the cause—flame spread, some plastics, unnamed free radical. **Page 20**

Package for data acquisition, analysis, graphics for scientific and engineering work is Macmillan Software's first product. **Page 22**

Books

"**Science and Creationism,**" a collection of essays on creationism and evolution, is organized aimlessly by Ashley Montagu. **Page 41**

Final Program

Complete technical program, list of social events, registration and housing forms necessary for Philadelphia meeting. **Page 96**

Cover: Ceramist Carl F. Bobik of General Electric examines graphite die used to make boron nitride samples

Special Report

R&D on high-tech ceramics is increasing in the search to replace metals and plastics, but ceramics' resistance to corrosion and high temperature is offset by their brittleness. **Page 26**

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European Zeolite Makers Bank on Catalysts, Detergents

Companies look to renewed growth in traditional markets to soak up excess capacity, but still hope for new catalyst applications

Patricia L. Layman, C&EN London

For the European zeolites industry, there is one basic problem: It's too big. Producers anticipating good growth in markets such as desiccants and adsorbents, fluid-cracking catalysts, and detergents, have jumped into the business, building merrily away. With growth temporarily slowed, producers are sitting on abundant capacity.

To their comfort, there probably will be few newcomers jumping into the business now. Indeed, the most recent entry into the European market was Union Carbide, which bought into fluid-cracking catalysts, acquiring the Dutch-based Katalistiks, rather than building its own capacity. Producers also can take comfort in the knowledge that their business is still growing, although not so rapidly as once expected.

That is rather different than the situation in the U.S., where to be a zeolites producer might not be the happiest of circumstances. Two of the U.S. market segments, desiccants/adsorbents and fluid-cracking catalysts, are doing as well as can be hoped. However, by far the largest market—detergents—is in a shambles, following the recent decision by Procter & Gamble to reverse an earlier decision to use zeolites as builders in its detergent products.

The second largest use for zeolites in the U.S. is for fluid-cracking catalysts (FCCs), far behind the amount used for detergents (C&EN, Sept. 27, 1982, page 10). In Europe, too, FCCs probably account for the second largest use of zeolites, following detergents. Although the market for FCCs themselves is roughly the same size as that for detergent zeolites, zeolites make up only a part of a formulated FCC—anywhere from 5 to 40%. The resultant difficulty of estimating the size of the FCC zeolite market in Europe is compounded by the almost complete lack of a merchant market for the product. Probably the only company selling zeolites to FCC producers on the merchant market in Europe is Degussa, which has decided not to enter the market for formulated FCCs.

European consumption of FCCs will amount to about 40,000 metric tons this year, less than one fourth the more than 170,000 metric tons used in the U.S., and slightly less than half the amount used by the rest of the world, excluding the U.S.

But it is a promising market, and growing, as a number of catalytic cracking units have been built in Europe. Demand is increasing about 5% per year, says one marketer, who points out that the number of cracking units in the U.K. alone has doubled over the past five years. Moreover, the average catalyst use rate in Europe is about 0.15 lb per barrel of oil; in the U.S., it is slightly higher, at about 0.2 lb per bbl. That encourages European marketers, who predict that European use will begin increasing as Europe gets heavier oil stocks to begin cracking.

For the time being, however, the industry has significant overcapacity, and industry observers had feared that Union Carbide—which everyone expected to get into this segment of the business sooner or later—would build its own capacity. There was almost a collective sigh of relief throughout the industry when Carbide bought the European producer of FCCs, Katalistiks. The company's three owners—English China Clays, the Swedish firm EKA, and Baltimore-based CRI International—sold out to Carbide for a reported $45 million.

With its purchase of Katalistiks, Carbide got into the business both in Europe and in the U.S. Katalistiks started up last year a 60,000 to 80,000 metric-ton-per-year plant in Savannah, Ga., to add to its Dutch capacity. And this market is increasingly becoming internationally competitive. Besides Katalistiks' move into the U.S., Akzo is building an FCC plant in Houston, with about 45,000 tons per year of capacity, due to begin operating next year. Akzo also has just announced plans to build another FCC plant, of 25,000 metric tons capacity, in Brazil.

Zeolite producers around the world, however, are broadening the scope for their product. The development of Mobil's ZSM-5 zeolite catalyst has stimulated extensive R&D, with its capabilities of converting methanol to olefins or hydrocarbons of high octane number (C&EN, Dec. 13, 1982, page 9). And New Zealand is operating a plant to convert natural gas to synthesis gas for methanol. In addition, the West German government is sponsoring two pilot coal-gasification plants using zeolite catalysts.

Imperial Chemical Industries in the U.K. is using Mobil catalysts at its *p*-xylene plant at Wilton, in the U.K., and BASF in West Germany until earlier this year was running a pilot plant, with 50 ton-per-month capacity, using zeolite catalysts for C_1 chemistry. It has shelved the project, the company says, only because abundant oil and gas supplies

Capacity for zeolites in Europe far outstrips demand

Thousands of metric tons	Nameplate capacity	Status	1984 demand
DETERGENT-GRADE ZEOLITES	225–260		120
Degussa	75	On stream	
Henkel	70	On stream	
Crosfield/Zinkwit	30–60	Announced	
Montedison	20	Announced	
Mira Lanza	15	Announced	
Rhône-Poulenc	10	Not operating	
Akzo	10	Not operating	
FLUID-CRACKING CATALYSTS	110		60[a]
Crosfield	35	On stream	
Akzo	30	On stream	
Katalistiks (Union Carbide)	25	On stream	
W. R. Grace	20	On stream	
DESICCANTS/ ADSORBENTS	25		12–15
Union Carbide	na	na	
W. R. Grace	na	na	
Laporte	na	na	
Bayer	na	na	
CECA	na	na	
Chemische Fabrik Uetikon	na	na	
Rhône-Poulenc	na	na	

a Includes 20,000 metric tons of exports. na = not available. Sources: Industry estimates, C&EN estimates

have alleviated the economic need for continuing it.

With that kind of potential, zeolite suppliers someday could have a market that could rival synthetic detergents. But that will not happen anytime soon. Despite the problems that zeolite makers are having in penetrating the U.S. detergent market following Procter & Gamble's decision not to use zeolite builders, producers in Europe see a detergent market that is already solidly established and set to grow.

In some respects, the use of zeolites at all in detergents is surprising. Henkel researchers, for example, recall that it was difficult at first, pushing the idea of putting an insoluble material at such high concentrations into a product that must be soluble.

Zeolites were being heavily investigated in the early 1970s, with patents filed by both Henkel and Procter & Gamble in 1973. Subsequent legislation helped encourage their use.

Early on Henkel had pooled its patents and know-how in manufacturing zeolites with those of Degussa, leading to a 50-50 joint venture, Sasil Patent Verwertungsgesellschaft, to exploit detergent zeolite manufacturing technology. Henkel licenses the application in detergents; the joint venture licenses production technology.

Use of zeolites is growing slowly in those areas where legislation affects phosphates—in West Germany, Switzerland, the Netherlands, and Italy, for example. Conversely, in countries where there are no regulations limiting phosphate use, phosphates remain the builder of choice.

One of the key points comes down to cost. If zeolites can be incorporated into a product on a sound economic basis, they are attractive to soap makers. On a 100%-dry basis, zeolites cost about 37 cents per kg in Europe, and phosphates cost 55 to 63 cents per kg. However, relatively more zeolite is used for a given formulation, and transportation costs mount up quickly, a disincentive unless the detergent plant is near a source of zeolites.

As some makers of detergent zeolites scramble to modify their products, marketers of adsorbent zeolites face a much stabler, mature market. The outlet as desiccants and adsorbents is probably the oldest for zeolites. Just as in the U.S., this market is the smallest of Europe's three major markets for zeolites; but within that segment, the European breakdown differs markedly from that in the U.S. European marketers split the desiccants and adsorbents market into two parts: static adsorption, the desiccant function of zeolites in refrigerators or in double-glazing windows, for example; and dynamic adsorption, used for treating gases and liquids. In the U.S., about 80% of the market is for desiccants, with the remaining 20% going for adsorbent applications. In Europe, however, adsorbent uses predominate.

Both applications have seen hard times lately. The use of desiccants for double-glazing windows has fallen afoul of a general slowdown in construction, resulting in nearly 50% overcapacity in insulating glass manufacturing in West Germany alone—down from growth of more than 10% per year in more robust times. Suppliers of desiccants are waiting both for construction to pick up and for the inevitable replacement window market to develop.

And on the dynamic adsorption side of the business, zeolites producers have been affected by the low capacity utilization in ethylene. Not only have many ethylene plants been closed down in Europe, but those still running have been running at such low use of total capacity that the molecular sieves have been used up at a slower rate.

According to suppliers, it takes a great deal of time to develop a process to use with the appropriate zeolites. This is also difficult, in a market where "big" is probably a 5000 metric-ton-per-year plant in this specialized segment of the European industry. Carbide and Grace are vying for market leadership, although it is probably split, with Carbide the largest supplier in dynamic adsorbents and Grace the largest in the static market.

However, small markets also offer companies the ability to combine flexibility with innovation. That's the strategy suppliers such as Laporte Inorganics, Bayer, Chemische Fabrik Uetikon, Degussa, and the French firms CECA and Rhône-Poulenc are working on. □

NOTE

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JULY 16, 1984

CHEMICAL & ENGINEERING NEWS

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Chasing an elusive fuel market Page 9

CHEMICAL & ENGINEERING
NEWS

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JULY 16, 1984

News of the Week

- **Two GAO reports find that toxic chemicals regulations are inadequate.** **Page 6**
- **Sandia lab uses solar heat and molten salt system to generate electricity.** **Page 7**
- **Georgia-Pacific will retain specialty chemical and resin units related to its forest products business.** **Page 7**
- **League of Women Voters decries proposed changes in motor vehicle emission rules.** **Page 8**
- **Common Cause seeks Congressional investigation of FDA's approval of aspartame.** **Page 8**
- **NRC committee calls for research to develop better materials and maintenance systems for road surfaces.** **Page 8**

Cover: First factory-produced methanol-fueled bus operates daily as joint demonstration project of Golden Gate Transit District (San Francisco) and California Energy Commission. Photo courtesy of Celanese, which provides methanol fuel and engineering backup

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Business

Marketers of hospital supplies confront need to make products cost efficient under new medicare reimbursement system. **Page 18**

By 1990, Middle East producers of ethylene-based chemicals will edge out the U.S. as dominant world supplier. **Page 19**

Government

National Science Foundation's emphasis swings toward technology to spur U.S. competition in technological development. **Page 22**

Congress sets fiscal 1985 budgets for a number of federal agencies including four that support R&D activities. **Page 24**

Technology

Possible methanol process designs arise from current overcapacity of methanol and its potential use as a fuel. **Page 31**

ACS News

Official reports from the ACS Board of Directors' June meeting at Belmont center include committee reports. **Page 37**

Allocations to local sections, divisions, and C&EN will rise in 1985 along with the increase in members' dues. **Page 37**

News Focus

Methanol producers in U.S. must contend with overcapacity, import competition until the long-awaited fuel market bonanza arrives. **Page 9**

Large-Volume Fuel Market Still Eludes Methanol

Problems delaying development of potentially huge market mean U.S. producers must live with overcapacity, import competition, and little profit

Earl V. Anderson, C&EN New York

Du Pont applied to the Environmental Protection Agency last week for a Clean Air Act waiver that would allow the firm to blend up to 5% methanol and a minimum of 2.5% cosolvent alcohol with unleaded gasoline.

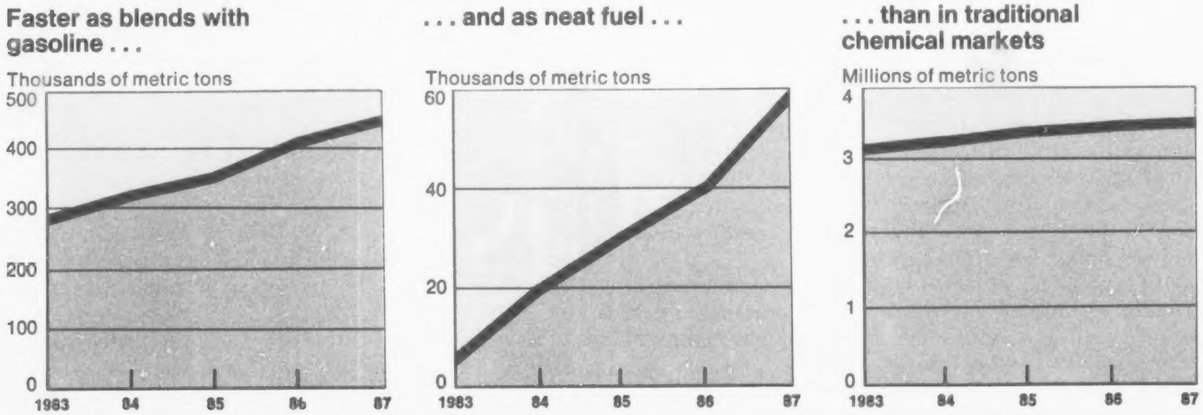
EPA denied a similar Du Pont waiver request last year because, according to EPA, there weren't enough evaporative emissions data. A Du Pont spokesman vowed that the company would not submit another request until it was positive that it would be accepted. Based on the research and testing that went into the new effort, it seems likely that, this time, Du Pont's waiver request will sail through.

If it does, it will be the first really good news for a beleaguered U.S. methanol industry in some time. And U.S. producers can use some good news, because they are squarely between a rock and a hard place.

The rock might be regarded as serious overcapacity and only slowly rising demand. In the U.S., and throughout the world, there is much more methanol capacity than consumers can possibly use—and more is on the way. Traditional chemical markets for methanol are mature, and thus growing slowly. Together, they are not soaking up all the methanol now available, not to mention the new capacity that hasn't started up yet. And even though exciting new uses await methanol in C_1 chemistry, these are a long way down the road. They will provide little relief for methanol producers until the 1990s. In the meantime, the world methanol situation is posing challenges for process designers (see page 31).

The hard place is the fuel market. This market was, and still is, the great hope of companies with too much methanol and not enough places to sell it. But the fuel market is proving to be a hard, and elusive,

How U.S. methanol demand will grow

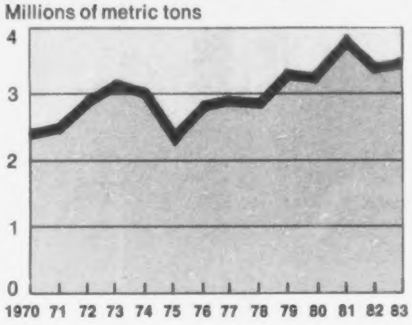


Note: Neat fuel is 100% or near 100% methanol. Traditional chemical markets include formaldehyde, solvents, acetic acid, methyl halides, methyl methacrylate, methyl amines, and dimethyl terephthalate. Methyl *tert*-butyl ether is not included. **Source:** DeWitt & Co.

place indeed. Despite all the attractions of methanol as an alternative fuel, the market is proving to be much tougher to crack than most producers imagined when they first geared up for an assault on gasoline's domain.

Estimates are difficult to pinpoint and they range all over the place, but probably less than 300,000 metric tons of methanol—about 8% of total U.S. consumption—went into fuels last year, after years of knocking on the door. That doesn't include the methanol that went into the octane extender, methyl *tert*-butyl ether (MTBE).

Methanol production has started to move up again



Source: International Trade Commission

The biggest problem, of course, is that energy economics have changed dramatically in recent years. In 1979 motorists in the U.S. and other oil-dependent nations suffered through their second oil crisis with its sharply curtailed supplies, painfully higher prices, and long lines at the gas pumps. At the time, alternative fuels became the order of the day. World attention focused on methanol.

Almost universally, the experts warned that crude oil prices would rise continuously. They warned that supplies could be tight for a long time, that disruptions were inevitable.

But the oil market crossed up the experts and almost everybody else. Energy conservation and a worldwide recession with its lower energy demand brought the rapid-fire increases in crude prices to a screeching halt. Now there is a glut in the world crude market and, barring a major political or military upheaval, crude prices are expected to rise only in line with inflation for the remainder of the decade. With smaller cars and their improved fuel efficiency, U.S. gasoline demand peaked in 1979. The sense of urgency that gripped alternative fuels five years ago has diminished, if not disappeared.

This new energy economics picture is perhaps the biggest, but certainly not the only, obstacle facing methanol's advance into fuels. Major oil companies aren't particularly happy about sharing their gasoline market with methanol. Several of them have launched heated campaigns to discredit methanol as a fuel. A flurry of "overblending" cases has triggered a stream of bad-press reports about methanol and the damage it has caused auto engines and other auto parts. Regulations—those now in place and some that are needed—create additional problems.

Although these and other problems are making it difficult for methanol producers to crack the fuel market in a big way, the companies haven't stopped trying. The prize—an immense outlet for their surplus methanol—is too valuable for them to give up on it. They are approaching the fuel market from every avenue possible, through neat (or nearly 100%) methanol, blends of methanol with unleaded gasoline (with or without a higher alcohol cosolvent), or via octane enhancers such as MTBE. In New Zealand, Mobil's direct MTG (methanol-to-gasoline) process is getting into the act. Almost everyone agrees that a neat methanol fuel system is the ultimate goal. This route avoids many of the problems created by methanol blends (which blend enthusiasts correctly argue can be overcome). The volumes involved in a neat methanol fuel market would be tremendous. Excess capacity would be used up in a hurry. More plants, in fact, would be needed.

But neat methanol fuel presents its own dilemma: Which should be developed first—supplies and a vast distribution system, or cars that will operate on methanol? Nobody seems willing to be first in making the huge investments necessary to make a neat methanol system work. On the supply side, a revamped distribution system would be necessary. But producers and distributors don't want to take the plunge until there is an assured market in the form of cars that can run on methanol. Automakers, on the other hand, don't want to pay the price of retooling for methanol cars until they are sure that their customers can find the methanol to fuel them. The result: investment paralysis.

So far, neat methanol hasn't made much of an impact on the fuel market. That market is limited to California, where extensive fleet tests have been under way for some time, and to a few other scattered test fleets. California is a leading champion of neat methanol, but last year probably no more than 5000 metric tons went into the fuel market as neat methanol.

Many experts feel that the dilemma facing neat methanol can't be solved by a freely operating marketplace alone. They say that the federal government will have to play a bigger role in developing a neat methanol market, just as the state government in California already is doing. In Washington, D.C., both Congress and the White House have taken a renewed interest in methanol, but what will come out of their efforts, and when, is difficult to predict.

Until government action or something else can break the impasse that haunts neat methanol fuel, most of the action—and most of the controversy—is taking place in methanol blends.

In the U.S. about 280,000 metric tons of methanol was blended into gasoline last year, along with higher alcohols as cosolvents, according to James R. Crocco, vice president of DeWitt & Co., Houston. Other estimates put the hard-to-pinpoint volume at twice that amount. Either way, it's nowhere near the quantity that methanol producers have been hoping for.

Methanol blends do have advantages. With methanol now costing about 42 cents per gal, and gasoline costing $1.20 or so per gal, the economics look good.

It's possible to use low percentages of methanol in unleaded gasoline with little or no modification to conventional cars. And blend advocates see it as a way to get the driving public tuned in to methanol until neat methanol becomes more widely accepted.

But blended methanol has its handicaps as well. Detroit isn't particularly enthusiastic about methanol blends. Some auto makers have threatened to void their new-car warranties if the cars are run on methanol-blended fuel. And some unscrupulous blenders, with an eye toward improving their profit margin, have illegally overblended methanol into unleaded gasoline. The resulting "horror stories" in the press about drivability problems and engine damage have given methanol blends a bad name and have made it more difficult for honest blenders to market their fuel. Some major oil companies, concerned about methanol's infringing on their gasoline market, also have spread the word about blended methanol's misfortunes and disadvantages.

Perhaps blended methanol's biggest technical disadvantage is its moisture problem. Even minute amounts of moisture destabilize the methanol-gasoline mixture. Metal corrosion becomes a serious problem when phase separation occurs. That's where cosolvents come in. When heavier alcohols are added to methanol, its water tolerance improves markedly.

On the regulatory end, methanol blends require an EPA waiver from the provisions of the Clean Air Act. Section 211(f) of that act prohibits selling new unleaded fuels, or fuel additives in unleaded fuels, without EPA approval. EPA will grant waivers if it is satisfied that the fuel or additive will not cause violations of vehicle emission standards.

Several methanol waivers have been granted, and several have been denied. Sun Oil Products received a waiver for an additive consisting of equal parts of methanol and *tert*-butyl alcohol (TBA) to total 5.5% alcohol.

Anafuel Unlimited (now American Methyl) also received a waiver for its proprietary fuel, Petrocoal. This product is a combination of methanol, C_4 alcohols, and a proprietary corrosion inhibitor in unleaded gasoline. The waiver allows up to 12% (by volume) methanol, up to 6% C_4 alcohols, and no greater than 15% total alcohol. The ratio of methanol to C_4 alcohols may not exceed 6.5 to 1.

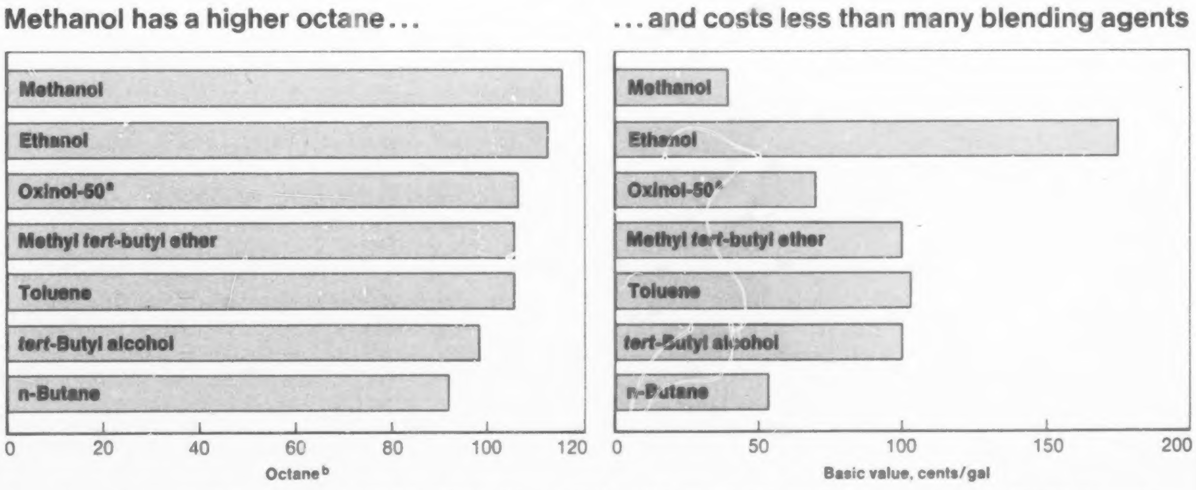
Earlier this year, EPA formally issued a notice that it was considering revoking the Petrocoal waiver because of its concern about evaporative emissions. This is a first-of-its-kind step for EPA, which was pressured by, among others, the auto companies through the Motor Vehicle Manufacturers Association.

It may take a long time before the legal knots of the Petrocoal waiver revocation are untied. Meanwhile, Petrocoal sales have been hurt by the publicity. That, in turn, hurts blended methanol volumes moving into the fuel market, because Petrocoal is one of the sales leaders.

The other sales leader is Oxinol 50, Atlantic Richfield's blending agent containing half methanol and half gasoline-grade TBA, or GTBA. Arco received its EPA waiver for Oxinol in 1981. Neither the methanol nor the GTBA may exceed 4.75%, and the ratio of the two products must be 1:1. The waiver also stipulates that total oxygen content may not exceed 3.5%, which makes it comparable to that of gasohol (10% ethanol and 90% unleaded gasoline).

Of the methanol waiver requests that were denied, the most surprising was Du Pont's. The company applied for a waiver that would permit blends of up to 3% methanol in gasoline, with or without a cosolvent. EPA denied the request because of inadequate emissions data.

However, Du Pont's application also received stiff opposition from the auto industry and California. Their concerns: corrosive effects on engine and fuel system parts, escaping volatile methanol vapor, increased


Methanol has a higher octane...

...and costs less than many blending agents

a Arco Chemical's gasoline blending component containing 50% by volume methanol and 50% gasoline-grade *tert*-butyl alcohol. b Average of research and motor octane. **Source:** Ethyl Corp.

Octane improvement costs can be negative with methanol

Cents per octane-number-barrel[a]	Volume, %	Octane improvement costs Unleaded regular	Unleaded premium	Leaded regular
Ethanol at $1.76/gal	10.0%	155.4	177.6	201.8
5 cents/gal gasohol subsidy	10.0	79.8	88.2	105.9[b]
10 cents/gal gasohol subsidy	10.0	4.3	−1.2	10.0[b]
Ethanol at $1.76/gal	5.0	173.9	195.0	231.4
***Tert*-butyl alcohol at $1.00/gal**	16.0	81.2	114.2	66.1
***Tert*-butyl alcohol at $1.00/gal**	8.0	88.5	125.5	72.0
Oxinol 50[c] at 70 cents/gal	9.6	5.4	0.0	9.7
Oxinol 50[c] at 70 cents/gal	4.3	31.0	30.6	37.3
MTBE at $1.00/gal	11.0	45.1	49.0	41.7
MTBE at $1.00/gal	4.0	48.8	52.6	45.2
Toluene at $1.05/gal	4.0	48.6	53.7	44.0
Methanol at 40 cents/gal	5.0	−19.0	−17.2	−29.2
Methanol at 50 cents/gal	5.0	−0.7	0.5	−2.3
Methanol at 60 cents/gal	5.0	17.5	18.1	24.7
Methanol at 70 cents/gal	5.0	35.8	35.8	51.6

a The cost required to increase 1 barrel of gasoline by one octane number. **b** Assuming gasohol subsidy applied to leaded gasoline. **c** Arco Chemical's gasoline-blending component containing 50% by volume methanol and 50% gasoline-grade *tert*-butyl alcohol. **Source:** Ethyl Corp.

evaporative emissions, and increased aldehydes in the exhaust.

Du Pont started working on a new formulation and collecting data for a new waiver request. Industry insiders speculated that Du Pont would put its application on hold until the Petrocoal waiver revocation issue was settled. But the company submitted its new waiver request to EPA last week.

Industry insiders were right about one thing, however. As they suspected, the waiver request calls for blending up to 5% methanol in unleaded gasoline, with a minimum of 2.5% cosolvent alcohol. The cosolvent, says Du Pont, could be ethanol, propanols, or butanols. The blending agent also would contain a new Du Pont corrosion inhibitor.

It appears, then, that Du Pont soon will join Arco and American Methyl in fighting for methanol blends. They can use all the help they can get, as excessive blending of methanol above allowable limits has led to a rash of consumer problems and legal action in several states. In most cases, the illegal blends were marketed by blenders and retailers rather than by refiners.

But the outbreak of horror stories that followed these events tarred the good guys along with the bad. And antimethanol advertising by several oil companies, including Amoco and Marathon, hurt sales of even properly blended methanol. Arco has counterattacked with an advertising campaign of it own, extolling the virtues of its Oxinol-gasoline blends.

Many of the performance problems associated with methanol blends can be solved with technology. But monitoring improper blending can't be, and it may be the toughest problem of all.

All U.S. car manufacturers have approved ethanol blends up to 10%; that is, gasohol. But they hedge when it comes to methanol blends. Most 1984 owners' manuals caution against using methanol-gasoline blends. Some have warned that certain levels of methanol may void warranty coverage.

Chrysler seems to be the most concerned. Since it is the only company to offer a five-year, 50,000-mile warranty, it warns against using gasoline with any amount of methanol in it and says that using it could void the warranty. Chrysler is anti methanol blends even when a cosolvent is used.

General Motors, however, indicates that up to 5% methanol with cosolvent may be acceptable. Ford advises that methanol-gasoline blends "may be injurious to the fuel system."

This concern on the part of auto companies, coupled with the outbreak of illegal overblending, has spurred a move toward pump labeling laws. Label advocates say that consumers should know what they are buying before it is pumped into their tanks.

Responsible marketers of methanol blends agree. Wayne D. Kuhn, Arco's vice president for oxygenated fuels, says that the industry must accept some standards for proper blending. "Indiscriminate blending doesn't help the industry," he says.

To help define these standards, producers and marketers of oxygenated fuels have formed the Oxygenated Fuels Association. The association supports efforts to develop effective label rules for pumps.

Properly blended, methanol in gasoline has several advantages. It can reduce particulate emissions, sulfur levels, hydrocarbon and carbon monoxide emissions, and cut NO_x levels. It also has a high octane value (116 vs. 87 for most unleaded regular gasolines).

Methanol has some attractive economics in its favor, too. Unlike ethanol, which can't make it into gasohol without state and federal tax subsidies, methanol can stand on its own feet economically. Even considering its energy content, which is lower than gasoline, methanol at 42 cents per gal works out to about 68 cents per gal as a gasoline extender, on a Btu-equivalency basis. Compared to 82-cent gasoline at the refinery, it's easy to see why overblending is profitable, even if selling methanol isn't. Additional value has to be credited to methanol for its higher octane rating.

Refiners will be increasingly hard-pressed to find additional octane. As older cars on the road are replaced by new ones that require unleaded gasoline, leaded gasoline will become less of a factor in the market. Dan Lundberg, respected publisher of the *Lundberg Letter*, says that, even without the accelerated lead phasedown that EPA is considering, leaded gasoline will represent only 20% of the market by the early 1990s. Its share was 46% last year and 66% in 1978.

This change alone will require a two-octane-number increase in the base gasoline pool. Refiners will be hard-pressed to meet it. They will be looking at all of their options, including octane extenders.

George H. Unzelman, technical director of Ethyl's chemical division, says that, from an economic standpoint, methanol looks very attractive as an octane extender. Unzelman has determined costs to raise 1 barrel of gasoline by one octane number, which he calls the cost per octane number barrel (ONB). He says that, with methanol at 50 cents per gal, octane improvement costs are about zero when 5% methanol is used in gasoline. If methanol costs less than 50 cents per gal, which it does, octane improvement costs are actually negative, says Unzelman.

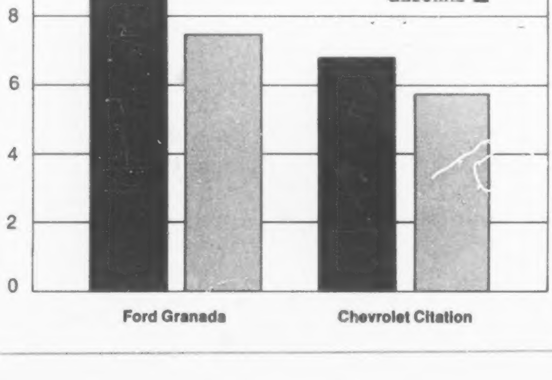
Methanol's octane economics are much better than those of ethanol (even with a 10% gasohol subsidy), TBA, MTBE, or toluene. Refiners that can, of course, will rely on processing to get their additional octanes. They have several options, but the two major units are the fluid catalytic cracker and the naphtha reformer. Not all refiners have the capability, however, to increase process severity.

One factor that doesn't show up in Unzelman's methanol ONB costs is the penalty for methanol's lower energy content, or Btu value. The refiner or blender of methanol and gasoline does get the full benefit of methanol's lower ONB costs, but the real value to the motorist, says Unzelman, is something less. With the energy penalty, the motorist pays more for the octane improvements afforded by methanol. He says this penalty ranges from 40 cents to 60 cents per ONB.

On a straight dollars-per-barrel basis, methanol has a ratio of 1 to 2 cost advantage over unleaded gasoline. It is expected to maintain that advantage for some time. However, Arco's Kuhn cautions about putting too much emphasis on methanol economics without figuring in the impact of cosolvent costs. He points out that methanol will not be used in commercial systems without a cosolvent; thus the cost of the cosolvent, as well as methanol, influences the economics of the mix.

Methanol blended with unleaded gasoline has advantages and disadvantages. But even most impartial observers agree that the advantages far outweigh the disadvantages. The one thing that blended methanol doesn't have that neat methanol does have is the problem of which to develop first, the proper auto engine or the fuel distribution system. For this reason alone, some methanol producers think that the market for blended methanol is worth pursuing. They feel that the blend market can serve as a bridge to an eventual neat methanol fuel market once all of its problems are overcome. During this transition period, methanol blends will grow and will provide the economic incentive needed to develop a network of methanol service stations.

Methanol shaved fuel costs in California test



Several pieces of legislation concerning methanol have been proposed in Congress

Bill and sponsor	Contents
H.R. 4855 Rep. Philip R. Sharp (D.-Ind.)	Federal fleets Reduce tax from 9 cents to 4.5 cents per gal Vehicle tax credit Buses Methanol commission
H.R. 5075 Rep. James T. Broyhill (R.-N.C.) Rep. Richard L. Ottinger (D.-N.Y.)	Federal fleets with replacement timetable DOE study Buses
H.R. 4975 Rep. Cecil L. Heftel (D.-Hawaii)	Reduce tax from 9 cents to 4.5 cents per gal
Amendment to Senate tax package Sen. John H. Chafee (R.-R.I.)	Reduce tax from 9 cents to 4.5 cents per gal

Source: Celanese Chemical

Not everyone, however, believes that developing a methanol blend market is worth the effort. Daniel Sperling, professor of civil engineering and environmental studies at the University of California, Davis, is one of these. He says that pursuing a methanol blend market "diffuses and dissipates" the larger effort of the entire industry to crack the neat methanol market.

He calls the blend route a "segmented" marketing strategy that doesn't generate any marketing expertise necessary for the neat methanol assault. It doesn't help get the distribution infrastructure in place, says Sperling, and it doesn't build the political and economic constituencies that could help develop and support a neat methanol market.

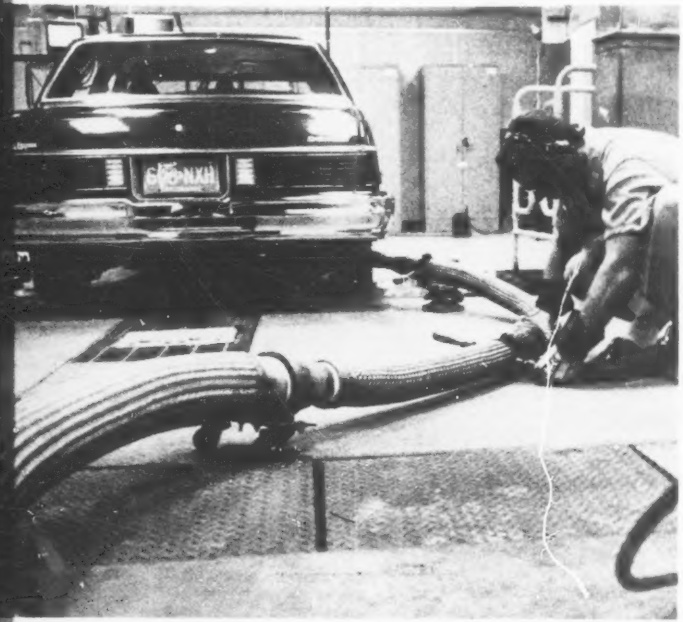
One area of the country that has forgone the blend route in favor of neat methanol is California. Methanol blending has remained "off limits" in California, says Charles R. Imbrecht, chairman of the California Energy Commission. But that is because the state's air quality regulations limit gasoline vapor pressure and it is difficult to meet these limits with methanol-gasoline blends. If a solution could be found to the vapor emissions problem, methanol-gasoline blends would receive "new consideration" as a way to create an initial market for methanol in California, says Imbrecht.

Meanwhile, state and private agencies are accumulating a lot of experience and data with neat methanol vehicles. There is a higher concentration of methanol-fueled vehicles on the road in California than anywhere else in the world, says Imbrecht. More than 25 service stations now dispense methanol throughout the state and more are planned. California alone is using about a million gallons of methanol per year and is accumulating neat methanol operating experience at the rate of more than 10 million miles annually.

In 1979, the state legislature appropriated $10 million to investigate alternative fuels. With some of this money, the California Energy Commission has been operating three test fleets. Fleet I contains 12 1980 Ford Pintos, four of them retrofitted for neat methanol. Fleet II has 40 1981 Volkswagen sedans and pickups. These include 11 methanol Rabbits and eight methanol pickup trucks—the first U.S. factory-produced fleet with state-of-the-art methanol fuel injection engines. Fleet III, in which there is an unusual amount of interest, contains 55 1981 Ford Escorts, with 40 of them station wagons engineered and modified to use 94.5% methanol.

This third fleet, operated by the Los Angeles County mechanical department, already has shown that carbureted methanol vehicles can provide reliable service to fleet operators. It also has shown lower NO_x, hydrocarbon, and carbon monoxide emission levels on a gram-per-mile basis with no sacrifice in fuel economy. In fact, fuel mileage was slightly better with neat methanol than with regular unleaded gasoline.

Based on the success of Fleet III, California issued a request for 500 1983-model methanol cars. Ford, the only bidder, supplied 500 Escorts, which are now in operation. They are the largest methanol test fleet in the world.



Du Pont analyzes exhaust emissions in its research on use of methanol in gasoline. Here a technician connects hose used to carry exhausts from auto to analytical equipment

Methanol capacity: plenty, even with two plants closed

Thousands of metric tons per year	Methanol capacity
Air Products & Chemicals/Pensacola, Fla.	180
Allemania Chemical/Plaquemine, La.	390
Arco Chemical/Channelview, Tex.	600
Borden Chemical/Geismar, La.	570
Celanese Chemical/Bishop, Tex., and	450
Clear Lake, Tex.	(690)[a]
Du Pont/Beaumont, Tex.	675
Deer Park, Tex.	600
Georgia-Pacific/Plaquemine, La.	360
Getty Oil/Delaware City, Del.	300
Monsanto/Texas City, Tex.	300
Tenneco/Houston	(390)[a]
Tennessee Eastman/Kingsport, Tenn.	195
TOTAL	**4620**

a Shut down. Not included in total.

The state has other neat methanol tests in progress, including heavy vehicles and transit buses. But one of the largest private methanol fuel programs is run by Bank of America. What makes the bank program stand out, among other things, is that it involves both neat methanol and methanol blends.

Bank of America began investigating alternative fuels in 1980 to protect its own huge vehicle fleet against another fuel shortage. Now it has accumulated more than 9 million miles of fleet experience with methanol. The corporation has a fleet of 2400 vehicles, and 292 of them have been converted. Its neat methanol fleet has 42 standard-compression General Motors vehicles and 250 higher-compression Ford vehicles. All of the remaining gasoline vehicles receive either 4% or 5% methanol blends (5% in San Francisco; 4% elsewhere).

Bank of America vice president Merle R. Fisher says that the bank tackled problems of materials compatibility, fuel contamination, and excessive engine wear head on. As a result, many of its cars have more than 50,000 miles on them and are still going strong, he says. By comparison, unprotected engines of the U.S. Postal Service had a useful life of only 15,000 miles.

Many fuel experts agree with the California enthusiasts who say that neat methanol has many advantages. It has greater thermal and fuel efficiency at higher compression ratios, more power than straight gasoline, less toxic emissions, is cooler and leaner burning, and probably has better fuel economy than regular gasoline.

To expand neat methanol's use and availability as a fuel to the country at large, Donald E. Petersen, president of Ford Motor, has suggested, on the automotive side, a four-step, phase-in program. It would grow, he says, from the current experimental fleet level to a "limited fleet" of 5000 to 10,000 vehicles annually in Phase II. In Phase III, annual volume would increase to 30,000 to 50,000 and the market focus would expand to regional sales. Phase IV would be full commercialization—nationwide, unrestricted sales of 250,000 to 350,000 vehicles annually.

But Petersen says that the auto companies would be foolhardy to move even into Phase II without assurance that subsequent phases will follow on schedule. And free market forces alone won't guarantee it, he adds.

His suggestion: more government action. A lot of neat methanol fans agree with him. California's Imbrecht, for instance, says that the state is approaching the limit of what it can spend on methanol development. He thinks that what's needed is a wider commitment on a national level to continue the government-industry effort that was started in California.

A flurry of methanol-related action is, in fact, taking place in Washington. Several pieces of methanol-related legislation are now before Congress. Some propose mandating methanol cars for federal fleets. Others suggest that methanol transit buses be bought with federal funds. Still others grant tax breaks for methanol fuel.

On the executive side, an interagency methanol working group has been formed to study just what the federal government can do to stimulate methanol's market growth in fuels. Already, for instance, EPA is formulating regulations for methanol vehicle emissions.

Some methanol producers contend that methanol's path into the fuel market runs through EPA's door. That is the agency that makes the regulations and hands out the exemptions.

It also is the agency that is considering banning or sharply reducing the amount of lead in gasoline. EPA is considering two options: an outright ban on lead antiknock agents, or the "low-lead option," which would reduce lead levels to 0.1 g per gal by 1988. The present allowable limit is 1.1 g per gal.

Methanol blenders are happy about the prospects. If either one happens, it will have a significant impact on alcohol fuels, says Arco's Kuhn.

Lower lead levels also will help methanol-based octane enhancer MTBE. With this compound, many of the problems associated with blended methanol don't surface. It causes no problems with the fuel or distribution system. MTBE's big drawback, however, is a shortage of precursor isobutylene. An estimated 240,000 metric tons of methanol went into the fuel market via MTBE last year. This could increase to about 340,000 metric tons by 1986, according to DeWitt's Crocco, to get the additional octane that will be needed. If there is enough available isobutylene, that volume could be higher. There certainly is no shortage of methanol to hold down MTBE output.

Another path for methanol to follow into the fuel market is Mobil's methanol-to-gasoline process. This process yields a high-octane, unleaded gasoline directly from methanol. The product from the process would be compatible with existing refining and distribution systems as well as existing cars, thus avoiding all the problems associated with methanol blends and neat methanol. But the economics aren't right for the U.S.

However, in New Zealand, which imports much of its petroleum, the first commercial methanol-to-gasoline plant will be on stream next year. The 12,500 bbl-per-day unit will be supplied by a new 1.5 million metric-ton-per-year methanol plant also being built in New Zealand.

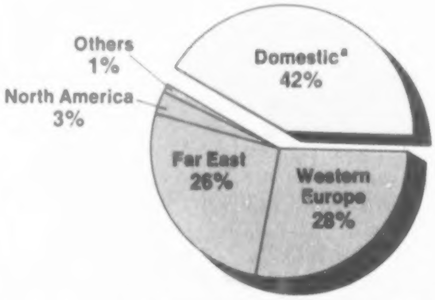
But no matter how hard or how many ways metha-

World will add 8.8 million metric tons of methanol capacity in three years . . .

Thousands of metric tons	New methanol capacity 1983	1984	1985
U.S.	**1080**		
Arco Chemical	600		
Tennessee Eastman	180		
Getty Oil	300		
Middle East/Africa	**660**	**660**	**660**
Saudi Arabia	660		660
Libya		330	
Bahrain		330	
Asia/Oceania	**390**	**858**	**1830**
New Zealand	390		1500
India		48	
Malaysia		660	
Burma		150	
Indonesia			330
Eastern Europe	**0**	**825**	**1485**
Soviet Union		825	825
East Germany			660
Western Hemisphere		**390**	
Trinidad		390	
TOTAL NEW CAPACITY	**2130**	**2733**	**3975**

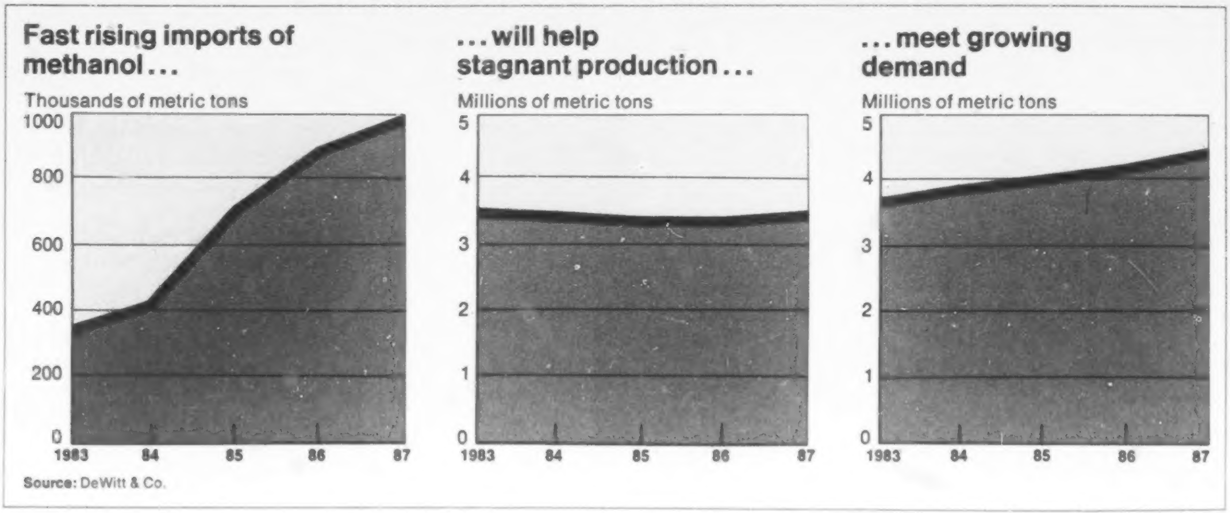
Note: Total global capacity at end of 1982 was 14.490 million metric tons, and at end of 1985 will be 23.328 million.

. . . and more than half of output from new capacity will be exported



1986 projected methanol destinations for new producers

[a] Use in producer country. **Source:** DeWitt & Co.


Fast rising imports of methanol . . .

. . . will help stagnant production . . .

. . . meet growing demand

Source: DeWitt & Co.

nol producers try to push their product into the fuel market, some experts insist that really large-volume shipments will escape them until the price of crude oil increases substantially. If that is true, U.S. producers will have to live with their overcapacity a few years longer.

And they will have to face the prospect of more import competition as new capacity comes on stream in resource-rich areas. Crocco estimates that, in a three-year time span, 1983–85, 8.8 million metric tons of new capacity will come on stream worldwide. More than 1 million metric tons of that already came on stream in the U.S. last year. The rest has gone and is going up in natural gas-rich areas in the Middle East, Asia, and Eastern Europe, particularly the Soviet Union. Saudi Arabia will be the big methanol force in the Middle East.

That 8.8 million metric-ton capacity addition is a hefty 61% of 1982's nameplate capacity and about 75% of last year's world methanol consumption. In just three years, world methanol capacity will have jumped from 14 million metric tons to more than 23 million metric tons. Crocco expects about 2 million metric tons of old capacity to be shut down, leaving a net of 21 million metric tons of capacity for the world to consume.

A lot of that new capacity will have little domestic demand, and the new producers will export much of their output. Crocco estimates that, of the 8.8 million metric tons of capacity coming on stream, 58% of it, or 5.1 million metric tons, will be available for export.

Western Europe will feel the biggest impact from this low-priced methanol, and Asia won't be far behind. Japan, a high-priced methanol producer, has been shutting down plants and switching to imports, especially from Saudi Arabia.

U.S. methanol imports will increase from last year's 300,000 metric tons to about 1 million metric tons in 1987. Most of this will be sourced closer to home, from Canada and Trinidad, but that won't make it any more welcome. U.S. methanol capacity, not even counting two plants that are shut down, is 4.6 million metric tons, much more than the 3.8 million metric-ton demand that is expected this year.

In a left-handed way, however, the imported methanol that is certain to come into the U.S. could help the U.S. methanol fuel market. It will be inexpensive, which is always helpful in opening up new markets. Methanol imported for fuel faces no U.S. duty, whereas methanol for chemicals has an 18.6% tariff. The difference in methanol tariff rates could be meaningless, however, for Trinidad and Canada if Trinidad is able to keep the duty-free status it enjoys under the generalized system of preferences and if Canada and the U.S. negotiate duty-free trade in petrochemicals, which has been proposed.

But, whether domestic or imported, the only sponge big enough to soak up the excess methanol is the fuel market. And this market involves more than just substituting for gasoline. Methanol has been suggested for a lot of fuel uses, from blending with or replacing diesel, to mixing with coal in a slurry. The most likely large-volume use, other than in gasoline, is as a fuel for stationary combustion turbines in peak load operations. This market, too, is hard to crack because utilities are reluctant to rely too heavily on methanol. They require a reliable and guaranteed source. Large volumes would be involved. Brownouts would be the penalty for slipups. Besides, the stabler price outlook for oil-based fuels has erased a lot of utility interest, just as it has in the gasoline market.

Crude oil prices are the key. They will determine the short-term future of methanol in fuel markets of all kinds. If crude prices remain low and stable, methanol will have to fight and scratch for every inch it gains along the road to the fuel market. If, for some reason, crude prices escalate, as they eventually must, then methanol's potential in fuel "boggles the mind," as Crocco puts it.

Meanwhile, U.S. methanol producers will have to live with overcapacity, low prices, little or no profit, and not much hope for relief until later in the 1980s. □

outstrip the rise of prices in general. In 1982, for example, the index of medical care prices rose 12%, whereas the Consumer Price Index increased just 6.0%. In 1983, the increases were 8.7% and 3.0%, respectively. And in the first quarter of this year, medical care prices rose 4.2%, compared to a mere 1.9% for the Consumer Price Index.

In response to hospitals' new cost consciousness, suppliers are scrambling to develop products that hospitals will buy because they reduce costs. The new focus is evident in both therapeutics and diagnostics. Abbott Laboratories, for instance, which gives much of the credit for its strong 1983 and first-quarter 1984 earnings performance to awareness of the new market realities, last month signed an agreement with Eli Lilly & Co. under which Lilly will offer its line of intravenous (IV) drugs, including injectable antibiotics, in an IV drug admixture system designed for intermittent administration of drugs that do not have long stability in solution.

Separately, Abbott also is marketing a system with which patients administer pain-relieving drugs by themselves intravenously in small, intermittent doses. Again, the company asserts, the system will cut hospital labor costs and add to drug use effiency.

In diagnostics, Abbott is introducing automated, high-volume clinical analyzers that it says will simplify test procedures, improve laboratory productivity, give more precise results in some cases, and make it possible for small and medium-sized hospitals to run tests on site that normally are sent to larger, higher-volume laboratories.

Other companies have moved to develop cost-efficient drug delivery systems as well. SmithKline Beckman recently received Food & Drug Administration approval to market Monocid, a cephalosporin antibiotic that can be injected just once daily instead of the typical three to four times a day. SmithKline says this should save hospitals money by reducing drug and administration costs, freeing nurses for other duties, and making it possible in some cases to release patients earlier to outpatient or home treatment.

In one study of four hospitals in Philadelphia, the difference in expenses between using Monocid and other cephalosporins was such that if the study institutions had used nothing but Monocid, they would have saved an average of $5.40 per patient day of therapy on antibiotic materials and labor, the company says, adding up to $103,000 per hospital per year on average.

And Baxter Travenol has been signing up other drug makers to package their cephalosporins in premixed form in the company's plastic container system. Baxter Travenol has such agreements with SmithKline for Ancef, with Merck & Co. for Mefoxin, with Hoechst-Roussel Pharmaceuticals for Claforan, and, most recently, with Fujisawa SmithKline Corp. (a joint venture of Fujisawa Pharmaceutical and SmithKline) for Cefizox. Approval from FDA is expected by the end of 1984, Baxter Travenol says.

Such development and marketing efforts are typical of the hospital supply industry's strategy for dealing with a market that has turned a sharp corner. It isn't that companies anticipate a moribund business concerned with nothing but reducing costs in the future; the general aging of the population is expected eventually to offset such effects. But they know that strategic changes are called for.

"Health care will continue to be a good business, but only for those manufacturers that help solve the cost problem," remarks Robert A. Schoellhorn, chief executive officer of Abbott Labs, in forecasting an 18% earnings increase for his company in the second quarter. "These are manufacturers whose products and services reduce overall health care costs, who provide the technology that makes the health care system itself more productive, and who can achieve the internal efficiencies necessary to stay competitive in an increasingly price-sensitive market."

David Webber, New York

Middle East will become major ethylene supplier

The U.S. will continue to be a major source of ethylene-based chemicals on world markets during the next several years. By 1990, however, it will be nudged out of its current position of dominant supplier by producers in the Middle East, primarily those in Saudi Arabia. On the other hand, the U.S. will retain its role as premier supplier of propylene derivatives.

These are among the conclusions presented recently by John A. Collins, head of the petrochemicals division of London-based Shell International Chemical Co., to the CHEMRAWN III conference in The Hague. CHEMRAWN, an acronym for Chemical Research Applied to World Needs, is an ongoing activity of the International Union of Pure & Applied Chemistry.

The way Collins sees it, U.S. net exports of ethylene-derived products in 1990 will amount to 2.20 billion lb ethylene equivalent. That will represent a 47% decline from the 4.18 billion lb in net exports in 1982. Over the same time span, Middle Eastern countries will swing from being net importers of 660 million lb to net exporters of 2.97 billion lb. Canadian net exports, meanwhile, could surge 500% from 110 million lb to 660 million lb.

Among the other trading areas, Western Europe likely will become a net importer of 1.2 billion lb ethylene equivalent in contrast to its net exports of 990 million lb in 1982. Net exports from Eastern Europe likely will remain steady at 440 million lb, and imports by Asian countries other than Japan are expected to continue unchanged at 2.64 billion lb. Imports into Japan, however, may rise 600% from 220 million to 1.54 billion lb.

Anticipated changes in the global trade balance of ethylene derivatives reflect changes likely to occur both in ethylene production and consumption totals. Collins looks for an increase of some 32% from about 75 billion lb in 1982 to 99 billion lb in 1990, on the assumption that overall production and consumption will remain essentially in balance. There will be variations, of course, at local levels.

Middle East will produce 6.2 billion lb of ethylene by 1990

	Capacity		Production		Consumption	
Billions of lb	1982	1990	1982	1990	1982	1990
ETHYLENE						
U.S.	38.15	38.19	24.68	31.46	21.69	29.26
Western Europe	34.72	32.03	22.44	24.86	21.69	26.40
Japan	12.34	9.86	8.23	9.24	8.23	10.89
Middle East	0	7.39	0	6.16	0	3.74
Others	26.93	35.73	19.45	27.28	23.94	28.71
TOTAL	112.14	123.20	74.80	99.00	75.55	99.00
PROPYLENE						
U.S.	—	—	12.76	19.45	10.99	17.60
Western Europe	—	—	12.76	14.87	12.62	15.40
Japan	—	—	5.50	7.44	5.29	7.92
Middle East	—	—	0	1.14	0	1.76
Others	—	—	9.68	14.30	11.80	14.52
TOTAL	—	—	40.70	57.20	40.70	57.20

Source: Shell International Chemical Co.

In the U.S., for instance, output is forecast to expand 28% to 31.5 billion lb, whereas domestic consumption will be 35% higher at 29.3 billion lb. West European production likely will move up 11% to 24.9 billion lb, but the increase won't be sufficient to meet the expected 1990 requirement of 26.4 billion lb, 22% greater than in 1982.

Japan's ethylene generation of 9.24 billion lb, although 12% more than in 1982, will fall short of the anticipated consumption of 10.9 billion lb, 32% more than in 1982. In the other regions of the world excepting the Middle East, 1990 ethylene production will amount to 27.3 billion lb, a 40% increase, and consumption will be 28.7 billion lb, 20% ahead of 1982.

But it will be in Saudi Arabia where production and consumption changes will be the greatest in the near term. In contrast to 1982 when there was no ethylene output capability there, 6.16 billion lb is expected in 1990, 6.2% of the world total output in that year and 2.42 billion lb more than local ethylene demand. Key is the plentiful availability of low-cost ethane extracted from natural gas that now is flared.

The U.S. has relied on natural gas-derived ethane as the main source of ethylene. But as Collins points out, this "has at least reached a plateau and could even decline. Any increased [ethylene] production will have to be based on liquid feedstocks. In contrast," he adds, "West Europe and Japan have had to rely almost entirely on cracking liquid feedstocks, predominantly naphtha."

For Europe, the situation will be partly alleviated with the startup next year of a cracker at Mossmorran, Scotland, using ethane from North Sea gas. The 1.1 billion lb-a-year output will be shared with Exxon and Shell, who are funding the project jointly. "With ethylene production at Mossmorran based on ethane effectively replacing a similar amount of production from naphtha, and with increased flexibility built into many existing crackers so that they can handle liquefied petroleum gas (LPG), gas oil, or heavier feedstocks, naphtha demand in Western Europe will almost certainly decline," Collins maintains.

Liquid feedstocks have the edge over ethane, however, in that cracking yields propylene as a coproduct of ethylene. The actual amount varies with the feedstock and the cracking conditions. Thus, "the term 'propylene capacity' is somewhat elastic, and the concept can be even misleading," Collins notes.

Also, the volume of propylene produced during ethylene manufacture is insufficient to fulfill the needs of the chemical industry, and must be augmented by product recovered from oil refinery streams. "The greatest use of refinery-derived propylene occurs where ethylene manufacture is based on ethane cracking," Collins adds, "and where gasoline requirements necessitate significant catalytic cracking of heavier [grades of oil] products. It is not surprising that in the U.S. usage of refinery propylene for petrochemical purposes exceeds that of material from naphtha cracking."

He anticipates global propylene production will rise nearly 41% from 40.7 billion lb in 1982 to 57.2 billion lb in 1990. During those years, he projects U.S. demand will grow 60% to 17.6 billion lb. Next in terms of demand increase will be Japan (rising 50% to 7.92 billion lb), and Western Europe (22% to 15.4 billion lb). Propylene use throughout the rest of the world might expand 23% to 14.5 billion lb. The Middle East, which produces or consumes hardly any propylene right now, might need 1.76 billion lb by 1990, most of it recovered from refineries.

The U.S. will maintain its dominance as a supplier of propylene derivatives on world markets. In terms of propylene equivalents, exports in 1990 are projected to reach 2.2 billion lb, 43% more than in 1982. Canada and Eastern Europe will continue to be net exporters, probably at their 1982 levels (550 million lb for Canada and 330 million lb for the East bloc). Western Europe will move from being a net exporter (220 million lb in 1982) to a net importer (330 million lb) in 1990, as will Japan (220 million lb exports in 1982 to 550 million lb imports in 1990). Imports into Central and South America could decline 50% to 660 million lb. Imports into the Middle East, Africa, and other Asian countries likely will remain at their 1982 levels (220 million lb each for the Middle East and Africa, 1.10 billion lb for Asia).

"It has been postulated," Collins notes, "that with demand for propylene derivatives growing faster than for ethylene derivatives, this could upset the ethylene/propylene balance. Although the demand growth rate for propylene derivatives is some 20 to 25% more than the corresponding rate for those based on ethylene, it should not be overlooked that worldwide production and chemical demand for propylene in 1982 was less than 55% that for ethylene. Notwithstanding the growth rate differences, in 1990 it still will be less than 60% that for ethylene. Consequently, insurmountable problems in this decade need not be expected." □

cy in terms of research scaleup and technology transfer, the job would be better served by having an organization devoted just to that. We certainly have fallen behind other countries in those sectors. It could be a good investment on the part of the government. And I wouldn't be surprised if that view is now shared by many others in the scientific community."

NSF's Wilson is more cautious. "If the economically competitive disciplines continue to get modest increases," he says, "I would think any talk of establishing a special technology foundation would be muted. But if a much higher percentage of the NSF budget would go into engineering, I think you'd hear a groundswell of opinion to get the technologists off our backs." ☐

Budgets set for many federal R&D agencies

A number of federal agencies, including four that support R&D, find themselves in the almost unbelievable position of knowing three months ahead of time just how much money they will have to spend in the coming fiscal year. This represents quite a turnaround by a Congress that just two years ago couldn't manage to set final budget figures until three months after the Oct. 1 start of the fiscal year.

Among those lucky agencies is the National Science Foundation. Congress set its total budget at $1.5 billion, the amount requested by the Administration and approved by the Senate and $2 million more than the House-passed figure. But although funding for research and related activities will be $1.3 billion—only $6 million less than requested and $161 million more than is available this year—Congress did a lot of adding and subtracting in reaching that figure.

Computing accounted for most of the additions. Congress doubled the $20 million request for advanced scientific computing, that is, supercomputers, and increased about 50% the $6 million request for information sciences; the $4 million request for automation, instrumentation, and sensing systems; and the $3 million request for intelligent systems computer research. (The first addition was made by the House; the last three by the Senate; and all were accepted by the conferees that worked on the bill.)

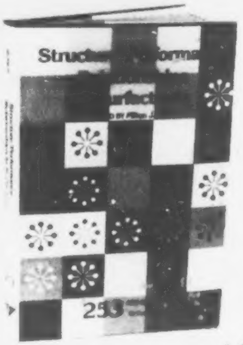
To keep the books somewhat in balance, Congress told NSF that it must cut $36.3 million from the research and related activities budget. It can do so anywhere it wants as long as the money doesn't come out of any of the above activities or the biological, behavioral, and social sciences directorate's budget.

NSF won't have to make any cuts at all in its science education activities, inasmuch as it will have 15% more money to spend than it actually wanted, or $87 million more, to be exact. These extra funds are to be used to restore the number of new graduate fellowships to the 1984 level of 600—NSF had intended to have 550—while at the same time increasing the annual stipend to $11,000 and the cost-of-education allowance to $6000.

The Environmental Protection Agency certainly won't have to do any belt tightening either. In fact, its only problem may be spending its money fast enough, particularly in the research area. Congress increased funding for extramural R&D 35% to $193 million. The Administration had wanted a mere 15% increase. Among the additional monies that EPA will have to spend are $5 million for health effects research, $4 million for hazardous waste control technology, $3.5 million for exploratory research grants and centers, $2 million for indoor air pollution research, and $1 million for pesticide research.

Funding for EPA's salaries and expenses account, which funds in-house research, will be $656 million. That figure is 14% higher than what is available this year and 3% more than the budget request. Congress suggests that the increased funding be used for hiring new employees to work on hazardous waste regulation, program implementation, and research; biological assessment of toxic chemicals; and evaluation and regulation of toxic chemicals.

Structure/ Performance Relationships in Surfactants



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Milton J. Rosen, *Editor*
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Congress sets its own funding priorities

$ Millions	1985 Appropriation	1985 Request	1984	% change 1984-85
NASA	**$ 7,491.4**	**$ 7,491.4**	**$ 7,197.5**	**4%**
Space-flight control and data communications	3,601.8	3,600.3	3,791.6	−5
R&D	2,422.6	2,400.1	2,011.9	20
Research and program management	1,317.0	1,331.0	1,238.5	6
Facilities	150.0	160.0	155.5	−3
Energy	**3,790.8**	**3,871.7**	**3,479.6**	**9**
Energy supply R&D	**2,027.2**	**2,039.7**	**2,012.6**	**7**
Nuclear	626.3	623.0	674.6	−7
Supporting research and technical analysis	481.0	479.6	395.1	22
Fusion	440.1	483.1	470.7	−6
Environment	229.7	226.2	216.0	6
Solar	179.4	163.6	181.6	−1
Electric energy systems and storage	38.6	37.1	44.2	−13
Geothermal	32.1	27.1	30.4	6
Weapons R&D	**1,036.0**	**1,085.2**	**825.8**	**25**
General science and research	**727.6**	**746.8**	**641.2**	**13**
NSF	**1,501.8**	**1,501.9**	**1,320.3**	**14**
Research and related activities	1,301.9	1,308.2	1,140.3	14
Antarctic program	110.1	115.1	102.1	8
Science education activities	87.0	75.7	75.0	16
Scientific activities overseas	2.8	2.9	2.9	−3
EPA	**1,296.8**	**1,198.7**	**1,111.5**	**17**
Salaries and expenses[a]	656.3	639.3	574.9	14
Abatement, control, and compliance	447.5	396.0	393.9	14
R&D	193.0	163.4	142.7	35
TOTAL	**$14,080.8**	**$14,063.7**	**$13,108.9**	**7%**

[a] Includes in-house research funding

Funding for the abatement, control, and compliance account, which EPA uses to enforce its regulations, will be almost $448 million, about 14% more than both the request and this year's funding level. Congress directed that state grants programs be increased by at least the following amounts: $7 million for water; $5 million for hazardous waste; $3 million for air; and $1 million each for drinking water, underground injection control, and pesticide enforcement.

Congress increased funding for the Department of Energy's energy supply R&D activities 7% to $2.0 billion, just slightly less than the Administration had requested. However, that doesn't mean that every program is getting an increase over fiscal 1984 funding levels. One that is is basic energy sciences, funding for which will be up 26% to $426 million. Within that category funding for chemical sciences will rise 15% to $95.1 million, and funding for materials sciences will increase 25% to $194 million.

The materials sciences budget will include $11 million for the center for advanced materials at the University of California, Berkeley; $8.9 million for completion of the vitreous state laboratory at Columbia University; and $3 million to continue the national center for chemical research at Catholic University.

Congress' total budget for the Nation Aeronautics & Space Administration is exactly in line with the Administration's $7.4 billion request, including the 20% increase requested for R&D. The $2.4 billion R&D budget, rearranged a bit from the request, includes $150 million for a space station; $195 million for development of a space telescope; and $120 million for the γ-ray observatory. The final version of NASA's R&D budget is in line with the version approved by the House (C&EN, June 18, page 17).

Janice Long, Washington

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By Aleksander Kreglewski

This book provides information on how the Helmholtz free energy or the equations of state of real fluids are related to intermolecular energy in nonelectrolytes. Numerous examples elucidate phase equilibria calculations. The book includes analysis and discussion of the basic relations of classical thermodynamics derived for multicomponent systems based on the residual functions of real fluids; the effects of intermolecular forces and molecular size differences on the properties of fluid mixtures; equations of state based on accurate relations for hard convex bodies; critical states of mixtures and phase equilibria at high pressures; thermodynamic properties of mixtures of simple molecules at low pressures and in very dilute solutions (gas solubilities in liquids) as well as the methods of smoothing experimental data; calculations of the properties of mixtures with complex interactions; and problems of separation of mixtures forming azeotropes. *256 pp. Figs. Tables. Bib. Index. $32.50*

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new concepts in pest control
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CHEMICAL & ENGINEERING
NEWS

Volume 62, Number 30
CENEAR 62 (30) 1–90
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JULY 23, 1984

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- **U.S. chemical companies' profits continue to increase robustly in second quarter.** Page 6
- **Merrell Dow Pharmaceuticals will set up $120 million fund to settle claims involving Bendectin.** Page 7
- **Eastman Kodak chemical division will move animal nutrition research to new facility to be built at Kingsport, Tenn.** Page 7
- **Two candidates for the ACS Board of Directors have been nominated by petition.** Page 7
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Cover: Photo courtesy of Uniroyal

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Business

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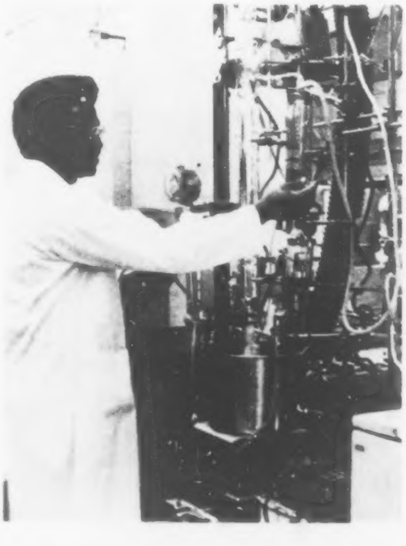


Special Report

U.S. spending for chemical R&D this year is expected to rise 12% to almost $12 billion; basic research is growing most actively. Page 37

Environment Council Report Stresses R&D

The President's Council on Environmental Quality released its 14th annual report last week, amidst one of the hottest periods of environmental activity in Washington, D.C., in recent years.

Environmental groups were appalled when the President appointed former Environmental Protection Agency Administrator Anne M. Burford to a federal advisory panel at the National Oceanic & Atmospheric Administration. However, the President saw no problem with the appointment and he proceeded to go on a highly publicized three-day environmental goodwill tour. It was on this trip, while visiting Theodore Roosevelt Island (named after the President who championed wildlife and conservation) in the Potomac River that Reagan released CEQ's report.

CEQ reports often are viewed as platforms that give an Administration credit for whatever it has done well and avoid talking about what it has not done well. They are traditionally divided into the various resources that are polluted—water, land, or air. But this year's report devotes scant attention to these traditional areas, mostly pointing out that improvements begun in the 1970s have continued.

One section that is a departure from past reports is an entire chapter devoted to the state of environmental research and development. CEQ divides the government's efforts into four categories, then discusses each separately. These are environmental health research, which includes toxicology, epidemiology, and clinical studies; ecosystems research, greatly concerned with predictive mathematical models and studies of existing patterns; environmental processes, where the whole range of chemical and biological cycles is studied; and technology research, which includes forecasting the effects of technological changes on the environment, as well as the monitoring and control of pollutants.

Broken down this way, it is interesting to find that EPA is only the fourth largest funder of environmental research. Basic research funded by the National Science Foundation, and toxicological and epidemiological research funded by the Department of Energy and the National Institute of Environmental Health Sciences all outweigh the support from EPA. This scattered effort has given rise to a call for a national environmental research policy that would combine some of these efforts. CEQ believes that the time is not right for that, but does agree that there would be a substantial benefit from better coordination of research and sharing of the research results among federal agencies.

Two areas not receiving much space in the report are toxic wastes and acid rain. As the premier issues of public concern, the absence of lengthy discussions of their current status and cleanup programs is a disappointment. Three scattered discussions on acid rain are presented, one dealing with international problems, one with its alleged impact on water quality, and the third on the relationship of acid rain to sulfur dioxide and nitrogen oxide emissions. Much of the discussion seems to minimize the problem, with references to the natural acidity of rain and to the relatively few lakes in the Northeast that have lost fish from acidity. Still, with the awareness of this issue so high, more detailed analysis and data on the problem could have been expected.

Toxic wastes get similar short shrift, although there seems to be no attempt to sugarcoat the problem. The seriousness of abandoned toxic waste sites is adequately chronicled, and federal and state programs (as well as the efforts of environmental and industry groups) are also listed, but it is hard to get any perspective on the issues from the CEQ report.

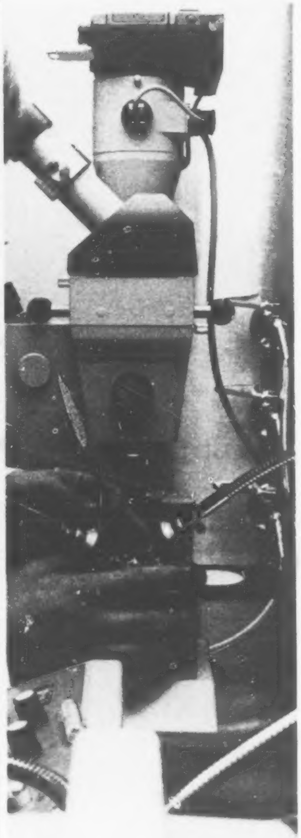
Copies of the CEQ report, Environmental Quality 1983, can be purchased for $8.00 from Superintendent of Documents, Washington, D.C. 20402, stock number 041-011-00077-7. □

Federal spending on environment research is widespread

$ Millions[a]	Environmental health	Ecological systems	Ecological processes	Technology
Defense Department	$ 5	$ 42	$ 25	$ 1
Energy Department	83	30	51	63
Environmental Protection Agency	50	24	37	49
Interior Department	0	9	20	2
National Aeronautics & Space Administration	0	0	32	0
National Cancer Institute	127	0	0	0
National Institute of Environmental Health Sciences	173	0	0	0
National Institute for Occupational Safety & Health	15	0	0	0
National Oceanic & Atmospheric Administration	0	11	29	0
National Science Foundation	0	40	277	6
National Toxicology Program	76	0	0	0
TOTAL	**$529**	**$116**	**$471**	**$121**

a Resources are approximate because of inconsistent agency interpretations of defined research. **Note:** Agriculture Department's environmental research is not included because it cannot be split out of larger programs.
Source: Council on Environmental Quality

Facts & Figures for Chemical



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R&D

Among the significant trends in U.S. spending for research and development this year is the increasing emphasis on basic research. Total spending by all sources for such research is expected to rise 12% to $11.9 billion in 1984. (In contrast, outlays for basic research were up only 7% last year and 8% in 1982.) This year, total spending will grow 8% for applied research and 11% for development. Clearly, the area of most active growth today is basic research.

The federal government's support of basic research will rise 9% this year to $6.6 billion. At the same time, its support of applied research is expected to decline less than 1% to $8.0 billion.

The government's position was clearly stated early this year by President Reagan, who, in his annual budget message to Congress, described basic research as "a critical investment in the nation's future," that lays the foundation for "new technologies and industries that will maintain U.S. industrial leadership, create new jobs, and improve our quality of life."

The Administration believes that it must give substantial monetary support to basic research to fill the gap left by industry's primary interest in applied research and development—although industry does carry a sizable part of the basic research load. The government's support of basic research mainly takes the form of grants to universities, which perform the majority of the nation's fundamental research.

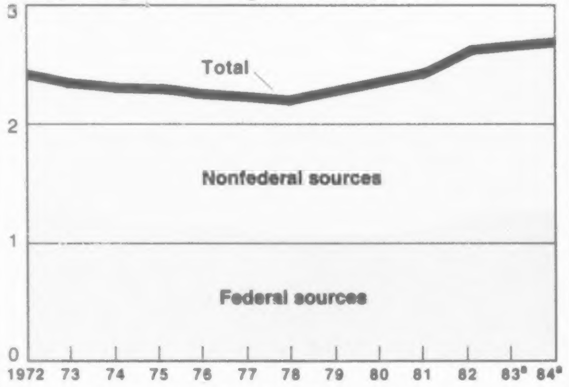
Another significant trend is the declining percentage of total funding for R&D coming from the federal government. In 1965, 65% of all R&D funds were supplied by the government and the remaining 35% by nonfederal sources. Now, the government supplies 46% of the total, whereas nonfederal sources (chiefly industry) furnish 54%. The government strongly endorses this trend because it believes that, if industry carries most of the financial burden for R&D, the results are more likely to reach the marketplace. Also, industry, it points out, is the chief financial benefactor of R&D.

Among other trends are the recent changes in the government's funding of R&D in its own departments and agencies. Most notable is that federal R&D funding of the Department of Defense increased a hefty 29% from $23.1 billion in fiscal 1983 to $29.7 billion in fiscal 1984. This reflects the Administration's emphasis on increasing U.S. military strength.

As evidence of the government's concern about expanding the nation's basic research effort, the National Science Foundation, which supplies a large share of federal money for basic research at universities, saw its total R&D funding rise to $1.24 billion in 1984—a gain of 17%. Of the NSF total, the support of basic research is up 18% to $1.18 billion in 1984.

R&D's share of GNP changed little in past three years

R&D spending as % of U.S. gross national product



a Estimated. Source: National Science Foundation

For some federal departments or agencies, however, funding for R&D has been cut in fiscal 1984. Among these are the departments of Agriculture, Commerce, Energy, and Interior, and the Environmental Protection Agency. These reductions are due partly to the Administration's desire to reduce federal spending and diminish the federal deficit. The Department of Energy's 2% drop in R&D funding between fiscal 1983 and 1984 is caused partly by reduced support for high-cost demonstration projects, such as synthetic fuel plants, coal liquefaction projects, and breeder reactors.

In 1984, total R&D spending as a percentage of the U.S. gross national product rose to 2.7%, the highest level in more than a decade. Six years ago, R&D's share of GNP was barely more than 2%. The present level is believed to be the highest for any nation in the world, with the possible exception of the Soviet Union. Many observers expect the U.S. figure to rise still higher in the years ahead, but obviously no one knows to what level it ultimately may climb. □

R & D funding to rise 11% this year

With basic research slated for a healthy increase, real outlays for R&D will score the heftiest gain since the mid-1960s

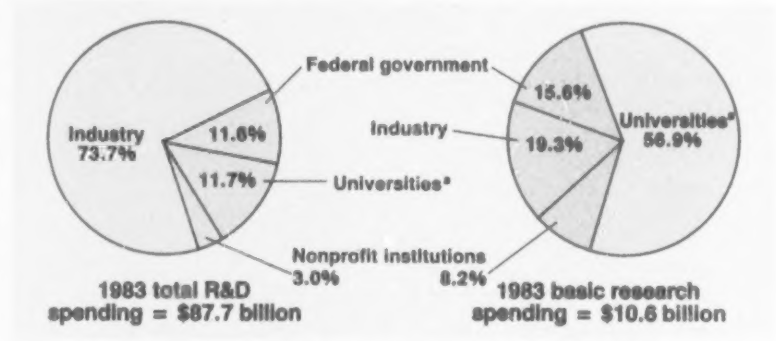
Total spending in the U.S. on research and development, according to the National Science Foundation, is expected to reach $97.0 billion this year, an increase of 11% over the 1983 level. In constant dollars, this constitutes a gain of 6%, well above the 4% average annual increase in R&D spending over the period of 1974 to 1984 and the biggest annual gain since the 1960s.

For the past five years, industry has been the leading supporter of R&D. In 1980, 49% of all R&D funds came from industry, 47% from the federal government, and the remaining 4% from other sources. In 1984, industry's share will rise to 51%, that of the government will decline to 46%.

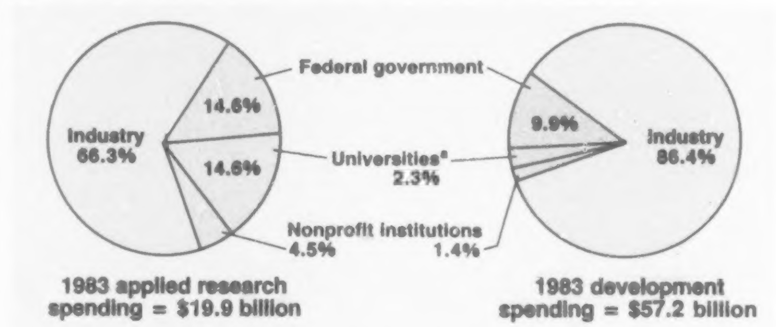
For decades, industry, partly with financial help from the federal government, has been by far the chief performer of R&D. Back in 1974, industry spent 70% of all the money expended on the performance of R&D, whereas the government spent 15%. In 1984, 74% of R&D money will be spent by industry and 11% will be spent by the government.

Universities, as they have for some years, do most of the nation's basic research. On the other hand, industry performs the bulk of the applied research and development work. ☐

Despite the universities' key role in basic research, nearly three fourths of all R&D is done by industry . . .



. . . because industrial firms perform by far the biggest portion of applied research and development work



[a] Includes associated federally funded research and development centers.
Source: National Science Foundation

TRENDS IN R&D: **Defense R&D captures its biggest share of total R&D funding since 1973**

% of total outlays	1984[a]	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968	1967	1966	1965
Federal	46%	46%	46%	46%	47%	49%	50%	50%	51%	51%	51%	53%	56%	56%	57%	58%	61%	62%	64%	65%
Defense related	29	27	25	23	22	23	24	25	26	26	27	30	32	32	33	34	35	35	33	33
Space related	6	6	7	7	7	7	7	8	8	8	8	8	9	9	10	11	13	14	19	21
Civilian related	11	13	14	16	18	19	19	17	17	17	16	15	15	15	14	13	13	13	12	11
Nonfederal	54	54	54	54	53	51	50	50	49	49	49	47	44	44	43	42	39	38	36	35

a Estimated. **Source:** National Science Foundation

SOURCES OF R&D FUNDS: Industry maintains its lead as the largest source of R&D money . . .

$ Billions, current	1984[a]	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change 1983-84	Annual change 1974-84
Federal government	$44.3	$40.3	$37.1	$33.4	$29.5	$26.8	$23.9	$21.6	$19.9	$18.1	$16.9	10%	10%
Industry	49.4	44.4	40.5	36.0	30.9	26.1	22.5	19.6	17.7	15.8	14.9	11	13
Universities and colleges	2.1	1.9	1.7	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.7	12	12
Other nonprofit institutions	1.3	1.1	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.5	10	10
TOTAL	**$97.0**	**$87.7**	**$80.3**	**$71.9**	**$62.6**	**$54.9**	**$48.1**	**$42.8**	**$39.0**	**$35.2**	**$32.9**	**11%**	**11%**

a Estimated. **Source:** National Science Foundation

. . . although expansion in all sectors is slashed by inflation

$ Billions, constant (1972)	1984[a]	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change 1983-84	Annual change 1974-84
Federal government	$19.6	$18.6	$17.8	$17.1	$16.5	$16.4	$15.9	$15.4	$15.1	$14.5	$14.8	5%	3%
Industry	21.9	20.6	19.6	18.4	17.3	16.0	14.9	14.0	13.4	12.6	12.9	7	6
Universities and colleges	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	7	4
Other nonprofit institutions	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	5	4
TOTAL	**$43.0**	**$40.6**	**$38.7**	**$36.9**	**$35.1**	**$33.6**	**$32.0**	**$30.5**	**$29.5**	**$28.2**	**$28.8**	**6%**	**4%**

a Estimated. **Source:** National Science Foundation

PERFORMERS OF R&D: Industry spends about three fourths of all dollars for R&D . . .

$ Billions, current	1984[a]	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change 1983-84	Annual change 1974-84
Industry	$72.0	$64.6	$59.0	$51.9	$44.5	$38.2	$33.3	$29.8	$27.0	$24.2	$22.9	11%	12%
Federal government	10.8	10.2	9.1	8.4	7.6	7.4	6.8	6.0	5.8	5.4	4.9	6	8
Universities and colleges	8.6	7.7	7.3	6.8	6.1	5.4	4.6	4.1	3.7	3.4	3.0	12	11
Associated FFRDCs[b]	2.8	2.6	2.5	2.5	2.2	1.9	1.7	1.4	1.1	1.0	0.9	7	12
Other nonprofit institutions	2.8	2.6	2.4	2.3	2.2	2.0	1.7	1.5	1.4	1.3	1.2	9	9
TOTAL	**$97.0**	**$87.7**	**$80.3**	**$71.9**	**$62.6**	**$54.9**	**$48.1**	**$42.8**	**$39.0**	**$35.2**	**$32.9**	11%	11%

a Estimated. **b** Federally funded research and development centers administered by universities and colleges. **Source:** National Science Foundation

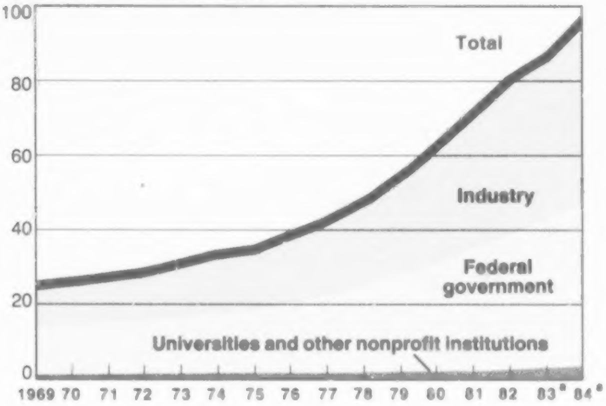
. . . and makes a big gain in spending this year in constant dollars

$ Billions, constant (1972)	1984[a]	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change 1983-84	Annual change 1974-84
Industry	$31.9	$30.0	$28.5	$26.6	$24.9	$23.4	$22.1	$21.3	$20.4	$19.2	$19.9	7%	5%
Federal government	4.8	4.7	4.4	4.3	4.3	4.5	4.5	4.3	4.4	4.3	4.4	1	9
Universities and colleges	3.8	3.5	3.5	3.5	3.4	3.3	3.1	2.9	2.8	2.8	2.7	7	3
Associated FFRDCs[b]	1.2	1.2	1.2	1.3	1.3	1.2	1.1	1.0	0.9	0.8	0.6	2	4
Other nonprofit institutions	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.0	1.0	1.0	4	2
TOTAL	**$43.0**	**$40.6**	**$38.7**	**$36.9**	**$35.1**	**$33.6**	**$32.0**	**$30.5**	**$29.5**	**$28.2**	**$28.8**	6%	4%

a Estimated. **b** Federally funded research and development centers administered by universities and colleges. **Source:** National Science Foundation

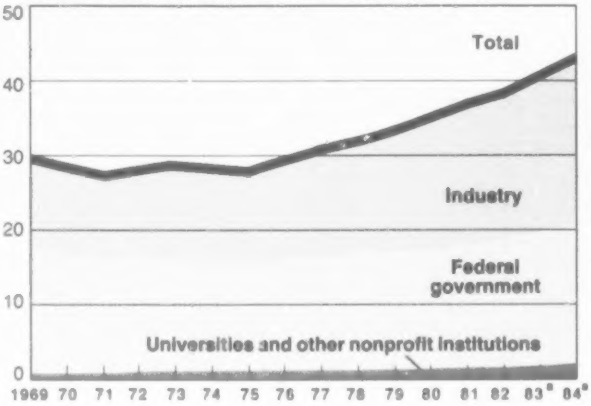
U.S. spending for R&D has increased steadily to near the $100 billion level . . .

Sources of R&D funds, $ billions, current



. . . and has managed to outdistance inflation since 1975

Sources of R&D funds, $ billions, constant (1972)



a Estimated. **Source:** National Science Foundation

CHARACTER OF R&D: Outlays for basic research will get a healthy boost this year . . .

$ Billions, current	1984a	1983a	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change 1983-84	Annual change 1974-84
Basic research	$11.9	$10.6	$ 9.9	$ 9.2	$ 8.1	$ 7.3	$ 6.4	$ 5.5	$ 5.0	$ 4.6	$ 4.2	12%	11%
Applied research	21.4	19.9	18.4	16.9	14.1	12.4	10.8	9.7	9.0	7.9	7.2	8	12
Development	63.7	57.2	52.0	45.8	40.5	35.3	30.9	27.5	25.0	22.7	21.4	11	12

a Estimated. **Source:** National Science Foundation

. . . but have shown the slowest growth, in real dollars, over the past decade

$ Billions, constant (1972)	1984a	1983a	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change 1982-84	Annual change 1974-84
Basic research	$ 5.2	$ 4.9	$ 4.7	$ 4.7	$ 4.5	$ 4.4	$ 4.3	$ 3.9	$ 3.8	$ 3.7	$ 3.8	7%	3%
Applied research	9.5	9.2	8.9	8.7	7.9	7.6	7.2	6.9	6.8	6.3	6.3	3	4
Development	28.2	26.5	25.1	23.5	22.7	21.6	20.5	19.6	18.9	18.1	18.7	7	4

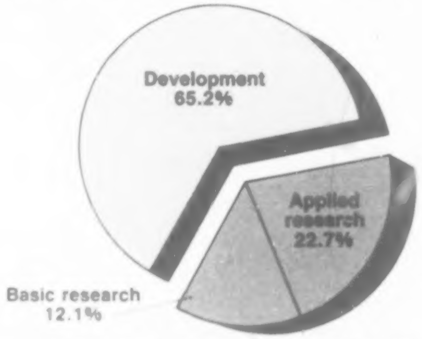
a Estimated. **Source:** National Science Foundation

EMPLOYED SCIENTISTS AND ENGINEERS: 8% are chemists and chemical engineers

	Thousands employed	Per cent
Scientists	**1405.8**	**43.2%**
Physical scientists	227.4	7.0
Chemists	154.1	4.7
Physicists/astronomers	47.6	1.5
Other physical scientists	25.7	0.8
Other scientists	1178.4	36.2
Engineers	**1847.2**	**56.8**
Chemical engineers	107.7	3.3
Other engineers	1739.5	53.5
TOTAL	**3253.0**	**100.0%**

Note: 1982 data. **Source:** National Science Foundation

Research itself accounts for little more than two thirds of total R&D outlays



1983 total R&D spending = $87.7 billion

Source: National Science Foundation

ABSTRACTS OF PAPERS IN *CHEMICAL ABSTRACTS*: Biochemistry's share dips slightly

% IN EACH GROUP	1983	1982	1981	1980	1979	1978	1977	1976	1975
Biochemistry	38.3%	39.5%	39.0%	39.8%	38.8%	38.3%	37.9%	38.8%	39.4%
Physical, inorganic, and analytical chemistry	29.6	28.5	28.0	28.6	28.9	27.4	27.9	27.5	29.6
Applied chemistry and chemical engineering	19.4	19.5	19.1	18.9	19.4	20.8	19.7	18.8	15.5
Organic chemistry	7.3	7.2	8.7	7.4	7.6	8.0	8.8	8.7	9.0
Macromolecular chemistry	5.4	5.3	5.2	5.3	5.3	5.5	5.7	6.2	6.5
% OF ALL BIOCHEMISTRY ABSTRACTS									
Mammalian biochemistry[a]	11.1%	11.6%	15.6%	16.3%	17.1%	17.2%	17.7%	16.3%	15.3%
Pharmacology	11.8	12.0	12.4	12.0	11.9	12.3	12.0	12.0	12.0
Toxicology	8.5	8.1	8.7	8.3	7.4	7.5	6.2	6.4	6.6
General biochemistry	5.8	6.0	7.5	6.6	7.0	6.5	7.0	7.1	7.5
Enzymes	6.1	5.9	5.9	6.2	6.4	5.7	6.1	6.4	7.4
Others	56.7	56.4	49.9	50.6	50.2	50.8	51.0	51.8	51.2
% OF ALL PHYSICAL, INORGANIC, AND ANALYTICAL CHEMISTRY ABSTRACTS									
Nuclear chemistry	22.5%	22.6%	21.6%	23.2%	25.1%	20.7%	21.1%	19.7%	20.0%
Spectra	17.6	17.2	18.0	18.2	17.0	17.0	18.1	17.8	17.2
Electric phenomena	10.0	10.5	11.0	11.2	11.4	10.9	10.5	10.5	10.3
Crystallography and liquid crystals	8.3	8.7	8.9	8.1	8.2	9.2	8.9	9.7	9.6
General physical chemistry	7.3	7.3	7.2	7.1	6.6	6.6	6.8	7.0	6.8
Analytical chemistry	6.2	5.4	5.8	5.6	5.6	7.2	5.8	6.6	6.1
Others	28.1	28.3	27.5	26.6	25.8	28.4	28.8	28.7	30.0
% OF ALL APPLIED CHEMISTRY AND CHEMICAL ENGINEERING ABSTRACTS									
Metals and alloys	19.1%	22.2%	17.9%	22.0%	23.6%	24.0%	24.2%	27.8%	24.4%
Water, wastes, and pollution	19.6	21.7	24.0	22.5	20.8	20.8	23.2	18.6	15.2
Mineralogical and geological chemistry	14.1	13.6	14.1	15.7	15.8	16.8	13.4	17.6	17.5
Fossil fuels, derivatives, and related products	10.3	9.4	9.4	8.9	7.8	8.2	9.2	6.0	9.8
Unit operations and processes	7.5	6.9	6.4	6.0	6.1	6.4	5.8	4.8	5.3
Others	29.4	26.2	28.2	24.9	2[illegible].9	23.8	24.2	25.2	27.8
% OF ALL ORGANIC CHEMISTRY ABSTRACTS									
Physical organic chemistry	30.5%	31.5%	37.0%	38.8%	38.8%	36.8%	41.3%	38.4%	40.8%
Heterocyclic compounds[a]	16.2	15.6	18.2	17.3	16.0	17.5	17.0	17.4	16.4
Organometallic and organometalloidal compounds[a]	16.3	14.8	8.3	8.2	8.5	8.9	8.5	8.7	8.4
Aromatic compounds[a]	7.1	7.2	8.7	7.8	8.2	8.6	8.5	8.0	8.7
Aliphatic compounds[a]	4.3	5.2	6.6	6.0	6.0	6.9	5.9	6.5	6.3
Carbohydrates	5.8	5.8	5.4	5.7	6.0	5.2	4.6	5.1	4.9
Others	19.8	19.9	15.8	16.2	16.5	16.1	14.2	15.9	14.5
% OF ALL MACROMOLECULAR CHEMISTRY ABSTRACTS									
Synthetic high polymers	34.4%	34.7%	30.3%	27.0%	26.3%	25.6%	26.5%	28.3%	30.6%
Plastics manufacture and uses	24.4	21.9	26.4	28.1	27.8	28.1	27.5	26.8	23.3
Cellulose, lignin, paper and other wood products	9.1	9.7	10.1	10.9	11.1	10.6	10.0	9.1	9.2
Textiles	7.9	8.9	9.9	10.1	10.1	12.1	11.0	11.1	10.2
Coatings, inks, and related products	6.6	7.6	7.5	7.4	8.1	7.5	7.5	7.6	7.3
Synthetic elastomers and natural rubber	7.5	7.8	7.9	8.4	7.6	8.0	8.5	8.6	9.2
Others	10.1	9.4	7.9	8.1	9.0	8.1	9.0	8.5	10.2

[a] Definition of section content changed in 1982. **Source:** Chemical Abstracts Service

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U.S. PATENTS: Total declines but percentage granted to foreign residents continues to rise

	1983	1982	1981	1980	1979[a]	1978	1977	1976	1975	1974	1973
U.S.[b]	32,872	33,896	37,356	37,152	30,605	40,979	41,383	44,162	46,603	50,643	51,501
Foreign[c]	23,990	23,993	24,463	24,675	18,248	25,123	23,886	26,074	25 291	25,632	22,638
TOTAL	**56,862**	**57,889**	**61,819**	**61,827**	**48,853**	**66,102**	**65,269**	**70,236**	**71,994**	**76,275**	**74,139**
% Foreign	**42.2%**	**41.4%**	**39.6%**	**39.9%**	**37.4%**	**38.0%**	**36.6%**	**37.1%**	**35.3%**	**33.6%**	**30.5%**

[a] Patent figures were low in 1979 because the Patent & Trademark Office was short of funds to print patents it might otherwise have issued. [b] U.S. patents granted to U.S. residents. [c] U.S. patents granted to residents of foreign countries. **Source:** Patent & Trademark Office

Defense wins most of this year's increase

FEDERAL OBLIGATIONS FOR R&D: Some major agencies suffer cuts in 1984

Department or agency	Total R&D ($ millions) 1984[a]	1983[a]	1982	1981	1980
Agriculture	$ 848.4	$ 852.9	$ 797.3	$ 774.0	$ 687.6
Agricultural Research Service	456.3	445.0	404.9	394.1	351.8[b]
Cooperative State Research Service	221.7	234.9	219.0	199.4	184.2[c]
Commerce	234.3	338.6	336.3	328.0	342.5
National Bureau of Standards	78.0	93.6	88.8	82.5	76.2
National Oceanic & Atmospheric Administration	142.1	220.5	222.0	201.4	199.8
Defense	29,735.5	23,125.1	20,622.6	16,508.6	13,981.0
Air Force	13,864.0	10,937.3	9,357.9	6,969.2	5,211.0
Army	4,904.1	3,965.0	3,760.5	3,244.2	2,980.0
Navy	8,063.3	6,043.7	5,845.1	5,006.0	4706.1
Defense agencies[d]	2,847.8	2,115.3	1,618.1	1,248.2	1,046.0
Energy	4,516.8	4,605.4	4,708.2	4,918.2	4,753.7
Environmental Protection Agency	207.7	240.8	335.1	235.7	345.0
Health & Human Services	4,434.8	4,326.7	3,940.7	3,927.1	3,780.2
National Institutes of Health	3,853.2	3,773.7	3,433.1	3,333.2	3,181.8
Interior	327.8	397.1	381.1	427.1	411.3
National Aeronautics & Space Administration	2,462.5	2,416.0	3,077.9	5,406.6	5,084.1
National Science Foundation	1,240.5	1,060.2	975.3	961.6	881.8
Tennessee Valley Authority	78.3	74.9	85.0	68.9	80.1
Others	1,410.4	1,272.4	1,173.1	1,271.6	1333.1
TOTAL	$45,497.0	$38,710.1	$36,432.6	$34,917.4	$31,680.4

a Estimated. **b** Agricultural R&D in Science & Education Administration. **c** Cooperative R&D in Science & Education Administration. **d** Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. **Note:** Fiscal years. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR RESEARCH: Funding for defense research jumps 13%

Department or agency, $ millions	1984[a]		1983[a]		1982		1981		1980	
	Basic research	Applied research	Basic research	Applied research	Basic research	Applied research	Basic research	Applied research	Basic research	Applied research
Agriculture	$ 380.8	$ 438.1	$ 363.3	$ 459.2	$ 330.8	$ 435.7	$ 314.1	$ 426.9	$ 275.7	$ 381.8
Agricultural Research Service	235.9	194.7	217.1	202.3	192.9	186.2	186.4	181.5	157.8[b]	170.8[b]
Cooperative State Research Service	95.6	126.1	97.6	137.3	91.3	127.7	83.9	115.5	75.2[c]	109.0[c]
Commerce	16.5	183.2	18.0	262.2	16.9	259.2	16.2	233.2	15.9	238.5
National Bureau of Standards	15.7	55.1	17.2	62.9	16.5	57.4	15.6	50.6	12.8	46.1
National Oceanic & Atmospheric Administration	0	118.6	0	187.4	0	188.5	0	168.5	14.0	154.8
Defense	868.5	2703.7	769.8	2391.7	686.7	2266.1	604.3	1996.6	540.3	1721.4
Air Force	206.6	526.0	157.6	499.0	145.8	488.1	125.8	491.5	108.2	429.1
Army	220.4	525.5	195.0	458.0	187.7	451.6	148.1	388.4	132.2	347.1
Navy	330.2	552.8	314.0	507.9	280.3	498.4	238.0	460.0	214.9	396.2
Defense agencies[d]	111.3	1099.4	103.3	926.8	72.9	828.1	92.4	656.7	85.1	549.1
Energy	800.8	1029.8	717.1	1251.5	642.2	1,053.9	586.3	827.3	523.1	754.2
Environmental Protection Agency	17.4	131.2	20.7	153.2	32.7	210.7	10.5	207.8	13.6	231.5
Health & Human Services	2468.1	1625.6	2388.4	1584.3	2144.7	1460.9	1900.4	1591.9	1762.7	1570.1
National Institutes of Health	2305.1	1217.7	2243.9	1199.4	2020.7	1103.8	1766.8	1181.5	1642.3	1145.1
Interior	89.7	220.7	100.0	268.7	76.5	275.0	80.7	289.2	71.6	282.8
National Aeronautics & Space Administration	681.5	965.4	604.7	956.9	535.7	871.4	531.1	876.0	559.1	1050.5
National Science Foundation	1181.1	59.4	998.5	61.7	916.1	57.1	896.6	58.9	815.2	58.4
Tennessee Valley Authority	5.7	7.5	5.5	10.0	4.6	8.1	4.8	9.4	4.6	11.2
Others	105.3	683.3	100.0	668.9	94.7	642.5	96.3	654.3	92.4	622.8
TOTAL	$6615.4	$8047.9	$6086.0	$8068.3	$5481.6	$7540.6	$5041.3	$7171.5	$4674.2	$6923.2

a Estimated. **b** Agricultural R&D in Science & Education Administration. **c** Cooperative R&D in Science & Education Administration. **d** Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. **Note:** Fiscal years. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR SCIENTIFIC DISCIPLINES: Chemistry makes good gain in 1984

$ Millions for research only	1984[a]	1983[a]	1982	1981	1980	Annual change 1983–84	Annual change 1980–1984
Engineering	$ 3,487	$ 3,501	$ 3,387	$ 3,072	$ 2,830	0%	5%
Chemical	108	139	95	148	96	−22	3
Metallurgy and materials	360	336	309	256	236	7	11
Environmental sciences	1,189	1,219	1,148	1,121	1,261	−2	−1
Life sciences	5,251	5,133	4,745	4,436	4,192	2	6
Mathematics and computer sciences	482	399	350	279	241	21	19
Physical sciences	3,179	2,852	2,500	2,221	2,001	11	12
Chemistry	529	477	481	487	455	11	4
Physics	2,078	1,867	1,611	1,346	1,183	11	15
Other sciences	1,075	1,050	892	1,085	1,072	2	0
TOTAL	$14,663	$14,154	$13,022	$12,213	$11,597	4%	6%

a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

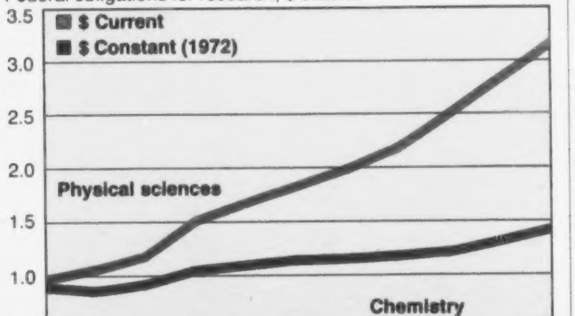
FEDERAL OBLIGATIONS FOR DEVELOPMENT: Defense takes a growing share of funds

Department or agency	Development ($ millions) 1984[a]	1983[a]	1982	1981	1980
Agriculture	$ 29.5	$ 30.4	$ 30.8	$ 33.0	$ 30.2
Agricultural Research Service	25.8	25.7	25.8	26.2	23.3[b]
Cooperative State Research Service	0	0	0	0	0[c]
Commerce	34.6	58.5	60.2	78.6	88.1
National Bureau of Standards	7.1	13.5	14.9	16.3	17.3
National Oceanic & Atmospheric Administration	23.5	33.1	33.5	32.9	30.9
Defense	26,163.3	19,963.6	17,669.8	13,907.7	11,719.2
Air Force	13,131.4	10,280.7	8,724.0	6,351.9	4,673.7
Army	4,158.2	3,312.1	3,121.3	2,707.7	2,500.7
Navy	7,180.3	5,221.8	5,066.4	4,308.0	4,095.0
Defense agencies[d]	1,637.1	1,085.2	717.1	499.1	411.9
Energy	2,686.2	2,636.8	3,012.1	3,504.6	3,476.4
Environmental Protection Agency	59.1	66.9	91.7	107.4	99.9
Health & Human Services	341.1	354.0	335.2	434.9	447.4
National Institutes of Health	330.4	330.3	308.7	384.9	394.4
Interior	17.3	28.4	29.6	57.3	56.8
National Aeronautics & Space Administration	815.6	854.4	1,670.7	3,999.4	3,474.4
National Science Foundation	0	0	2.2	6.1	8.1
Tennessee Valley Authority	65.1	59.4	72.3	54.7	64.3
Others	622.0	503.3	435.8	520.9	618.2
TOTAL	$30,833.8	$24,555.7	$23,410.4	$22,704.6	$20,083.0

a Estimated. b Agricultural R&D in Science & Education Administration. c Cooperative R&D in Science & Education Administration. d Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. **Note:** Fiscal years. **Source:** National Science Foundation

Government support for chemistry edges above half-billion-dollar mark

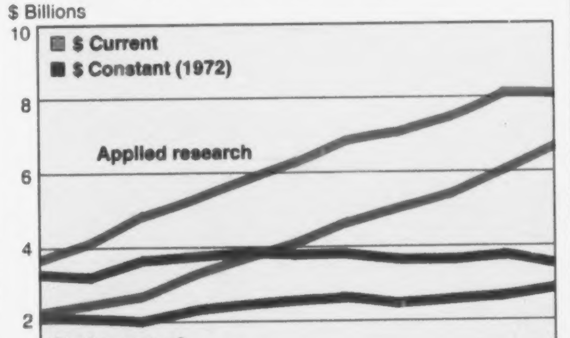
Federal obligations for research, $ billions



a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

Federal funds rise for basic research but drop for applied, in real terms

$ Billions



a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

R&D appropriations to research-oriented federal agencies for fiscal 1985 generally are up strongly

DEPARTMENT OF ENERGY R&D BUDGET: Funding has its ups and downs

$ Millions	1985 Congressional appropriation	1985 Administration request	1984[a]	1983	1982	% change 1984-85[b]
Defense R&D	$1036.0	$1085.2	$ 825.8	$ 742.2	$ 508.1	25%
General science and research	727.6	746.8	641.2	534.5	500.1	13
Nuclear	626.3	623.0	674.6	856.5	871.7	−7
Supporting research and technical analysis	481.0	479.6	395.1	293.2	269.6	22
Fusion	440.1	483.1	470.7	462.2	256.3	−7
Fossil energy	267.5[c]	200.0	260.2	217.1	417.7	3
Environment	229.7	226.2	216.0	182.5	213.6	6
Solar	179.4	163.6	181.6	203.0	252.4	−1
Conservation	139.5[c]	119.6	160.2	116.1	152.3	−13
Electric energy systems and storage	38.6	37.1	44.2	42.5	58.3	−13
Geothermal	32.1	27.1	30.4	78.2	41.3	6
TOTAL	**$4197.8**	**$4191.3**	**$3900.0**	**$3728.0**	**$3541.4**	**8%**

a Estimate. **b** Based on estimated Congressional appropriation. **c** Based on minimal action to date. **Note.** Fiscal years ending Sept. 30.

NSF BUDGET: Engineering and physical sciences are big gainers in an overall 13% increase

$ Millions	1985 Congressional appropriation	1985 Administration request	1984[a]	1983	1982	% change 1984-85
Mathematical and physical sciences	$ 418.5[b]	$ 416.7	$ 358.8	$ 300.4	$272.8	17%
Astronomical, atmospheric, Earth, and ocean sciences	366.9[b]	373.5	330.0	280.8	259.8	11
Biological, behavioral, and social sciences	256.1	253.1	223.6	191.2	176.6	15
Engineering	145.1[b]	147.1	120.7	101.1	93.3	20
Antarctic program	110.1	115.1	102.4	83.2	68.5	8
Science education activities	87.0	75.7	75.0	30.0	21.0	16
Program development and management	70.3	70.9	66.6	65.7	63.2	6
Scientific, technological, and international affairs	41.4[b]	46.9	40.8	44.1	40.3	1
Special foreign currency	2.8	2.8	2.9	2.2	3.1	−3
TOTAL	**$1498.2**	**$1501.8**	**$1320.8**	**$1098.7**	**$998.6**	**13%**

a Estimate. **b** Reflects one-quarter share of $36.3 million general unspecified reductions. **Note:** Fiscal years ending Sept. 30.

EPA R&D BUDGET: Congress tops Administration request, boosting funds above 1982 spending

$ Millions	1985 Congressional appropriation	1985 Administration request	1984[a]	1983	1982	% change 1984-85
Air	$ 75.9	$ 65.2	$ 62.3	$ 60.0	$ 63.2	11%
Energy	48.5	48.5	30.4	26.7	62.3	60
Hazardous waste	40.2	34.8	32.3	33.4	29.2	45
Toxic substances	34.8	27.1	24.4	26.8	34.1	43
Water quality	31.8	26.8	24.8	31.6	53.5	28
Drinking water	26.1	23.1	23.8	21.8	30.9	10
Interdisciplinary	23.9	20.4	21.3[b]	9.8	6.7	12
Superfund	12.7	12.7	8.8	6.9	13.8	44
Pesticides	10.0	8.0	6.3	6.1	7.1	59
Program management	9.3	9.3	8.5	8.9	7.9	9
Radiation	2.1	2.1	1.8	1.5	2.6	17
TOTAL	**$315.3**	**$278.0**	**$244.7**	**$233.5**	**$311.3**	**29%**

a Estimate. **b** Not an increase in total budget, reflects consolidation of other programs into the interdisciplinary program. **Note:** Fiscal years ending Sept. 30.

CIRCLE 39 ON READER SERVICE CARD →

NASA BUDGET: 20% increase for R&D as work starts on space station

	1985					
$ Millions	Congressional appropriation	Administration request	1984[a]	1983	1982	% change 1984–85[b]
Space flight, control, and data communications	**$3601.8**	**$3600.3**	**$3775.3**	**$3633.0**	**$2269.5**	**−5%**
Conduct of R&D	**2433.4**	**2399.7**	**2028.2**	**1902.5**	**2562.6**	**20**
Physics and astronomy	680.2	677.2	567.6	470.3	322.4	20
Space transportation systems	367.4	361.4	431.7	415.5	1271.8	−15
Space applications	384.1	344.1	291.0	347.7	324.3	32
Aeronautical research and technology	352.0	342.0	302.3	280.0	264.8	16
Planetary exploration	293.9	286.9	217.4	186.4	210.0	35
Space research and technology	154.0	150.0	137.0	124.5	111.0	12
Space station	150.0	150.0	—	—	—	—
Life sciences	63.3	63.3	58.0	55.7	39.5	9
Tracking and data acquisition	15.3	15.3	14.2	13.4	10.8	8
Technology utilization	9.5	9.5	9.0	9.0	8.0	6
General reduction	−37.5	—	—	—	—	—
Research and program management	**1317.0**	**1331.0**	**1258.5**	**1197.3**	**1109.2**	**5**
Facilities	**150.0**	**150.0**	**160.0**	**155.5**	**78.7**	**−6**
TOTAL	**$7502.2**	**$7481.0**	**$7222.0**	**$6888.3**	**$6020.0**	**4%**

a Estimate. **b** Based on Congressional appropriation. **Note:** Fiscal years ending Sept. 30.

DEFENSE R&D BUDGET: Another hefty boost despite cutbacks by Congress

	1985					
$ Millions	Congressional authorization[a]	Administration request	1984[b]	1983	1982	% change 1984–85[c]
Air Force	$13,280.8	$14,401.9	$12,220.1	$10,591.2	$ 8,659.6	9%
Navy	9,161.2	9,833.6	7,571.7	6,063.3	5,844.4	21
Army	4,574.3	4,987.7	4,259.7	3,875.3	3,609.5	7
Defense agencies	4,347.5	4,708.3	2,767.4	2,153.2	1,745.6	57
Director, test and evaluation	60.5	62.0	49.0	55.0	52.0	23
TOTAL	**$31,424.3**	**$33,993.5**	**$26,867.9**	**$22,738.0**	**$19,911.1**	**17%**

a C&EN estimate based on House and Senate passage. **b** Estimate. **c** Based on estimated Congressional authorization. **Note:** Fiscal years ending Sept. 30.

NIH BUDGET: Research on aging sets pace in a generally strong, broad increase

	1985					
$ Millions	Congressional appropriation[a]	Administration request	1984[b]	1983	1982	% change 1984–85[c]
National Institutes	**$4743.5**	**$4219.2**	**$4120.6**	**$3705.5**	**$3392.0**	**15%**
Cancer	1187.1	1101.1	1077.3	987.6	943.0	10
Heart, Lung & Blood	807.2	718.9	703.2	624.3	559.6	15
Arthritis, Diabetes & Digestive & Kidney Disease	545.6	475.3	462.5	413.5	368.2	18
General Medical Science	495.2	423.8	415.6	369.5	355.4	19
Neurological & Communicative Disorders & Stroke	401.4	344.6	335.2	297.1	265.5	20
Allergy & Infectious Diseases	372.5	325.4	314.1	279.1	235.8	18
Child Health & Human Development	312.1	280.1	275.2	254.3	226.2	13
Environmental Health Sciences	191.9	183.7	179.8	164.9	154.1	7
Eye	187.2	157.8	154.7	141.9	130.4	21
Aging	144.8	117.4	114.9	94.0	81.8	26
Dental Research	98.5	91.1	88.1	79.3	72.0	12
Research Resources	**303.5**	**245.7**	**242.6**	**213.9**	**184.1**	**25**
National Library of Medicine	**53.5**	**51.3**	**49.6**	**51.9**	**44.8**	**8**
Office of the director	**29.1**	**27.5**	**26.7**	**24.7**	**23.6**	**9**
Research facilities	**21.7**	**11.1**	**25.0**	**17.5**	**9.9**	**−13**
John E. Fogarty Center	**11.9**	**11.4**	**11.3**	**10.1**	**9.2**	**5**
TOTAL	**$5163.2**	**$4566.2**	**$4475.8**	**$4023.6**	**$3663.6**	**15%**

a Based on minimal action to date. **b** Estimate. **c** Based on estimated Congressional appropriation. **Note:** Fiscal years ending Sept. 30.

← CIRCLE 39 ON READER SERVICE CARD

BASIC RESEARCH: More than half of chemistry's support is from NSF and Energy Department

	Federal obligations ($ millions)									
	1984[a]		1983[a]		1982		1981		1980	
Department or agency	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	$ 42.8	$ 40.8	$ 40.2	$ 38.3	$ 36.2	$ 34.5	$ 33.7	$ 31.8	$ 25.8	$ 24.0
Agricultural Research Service	36.7	35.3	33.7	32.5	30.0	28.9	27.7	26.5	20.8[b]	19.6[b]
Cooperative State Research Service	3.7	3.7	4.0	4.0	3.8	3.8	3.4	3.4	3.0[c]	3.0[c]
Commerce	13.6	4.2	14.7	4.3	13.7	4.2	12.6	2.9	11.3	2.2
National Bureau of Standards	13.3	3.9	14.5	4.1	13.7	4.2	12.6	2.9	11.0	2.1
Defense	217.8	60.9	195.0	52.3	188.7	51.5	194.9	43.5	167.1	35.7
Air Force	46.4	17.9	35.1	14.5	34.2	13.9	32.3	12.9	24.8	10.4
Army	63.4	20.2	55.5	17.7	59.6	20.0	49.5	14.5	46.0	12.7
Navy	106.2	22.7	102.1	20.1	93.1	17.7	79.7	15.9	72.0	12.3
Defense agencies[d]	1.8	0	2.3	0	1.8	0	33.4	0.2	24.3	0.2
Energy	672.9	87.6	600.5	76.1	530.8	75.5	480.2	70.0	432.1	62.1
Environmental Protection Agency	1.5	1.2	2.0	1.7	3.8	3.5	2.9	2.9	2.3	2.3
Health & Human Services	61.4	55.6	58.8	53.2	53.2	48.0	53.2	48.0	53.7	47.4
National Institutes of Health	60.2	54.4	58.6	53.0	52.9	47.7	52.8	47.6	53.0	46.6
Interior	9.7	2.4	8.3	2.0	8.1	2.5	10.1	6.8	7.5	5.3
Geological Survey	3.2	2.4	2.6	1.8	2.8	1.9	3.0	2.0	2.6	1.7
National Aeronautics & Space Administration	351.9	5.3	337.0	5.5	280.6	5.2	268.9	6.6	309.0	5.2
National Science Foundation	346.5	105.7	287.4	88.5	266.6	83.3	254.8	81.5	198.6	68.4
Tennessee Valley Authority	3.7	3.7	3.4	3.4	3.0	3.0	3.1	3.1	3.1	3.1
Others	9.7	0.3	9.5	0.4	9.1	0.8	10.5	1.1	10.1	1.2
TOTAL	$1731.5	$367.7	$1556.8	$325.7	$1393.8	$312.0	$1324.9	$298.2	$1220.6	$256.9

a Estimated. b Agricultural R&D in Science & Education Administration. c Cooperative R&D in Science & Education Administration. d Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. **Note:** Fiscal years. **Source:** National Science Foundation

APPLIED RESEARCH: Chemistry receives 11% of funding for physical sciences this year

	Federal obligations ($ millions)									
	1984[a]		1983[a]		1982		1981		1980	
Department or agency	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	$ 26.4	$ 24.4	$ 27.8	$ 25.7	$ 26.0	$ 24.0	$ 25.0	$ 22.7	$ 26.9	$ 24.9
Agricultural Research Service	17.9	16.6	18.6	17.2	17.1	15.8	16.2	14.6	20.0[b]	17.8[b]
Cooperative State Research Service	6.3	6.3	6.9	6.9	6.4	6.4	5.8	5.8	5.4[c]	5.4[c]
Commerce	33.5	9.0	35.2	9.5	32.6	8.8	30.5	8.9	27.4	7.3
National Bureau of Standards	25.4	7.5	25.9	7.9	25.4	7.3	24.4	7.5	21.3	6.0
Defense	710.9	75.0	565.0	62.4	500.0	66.6	335.2	47.2	243.4	42.5
Air Force	55.2	14.6	53.0	13.9	50.5	13.3	49.7	14.3	41.5	12.5
Army	76.7	43.9	76.1	35.8	83.2	41.4	58.6	24.6	54.3	24.2
Navy	145.5	16.5	128.8	12.8	128.7	11.7	98.5	8.1	59.0	5.3
Defense agencies[d]	433.5	0	307.2	0	237.6	0.3	128.4	0.3	88.6	0.6
Energy	578.3	13.2	576.9	12.8	482.8	29.9	390.2	13.7	360.0	22.2
Environmental Protection Agency	11.7	10.7	13.8	12.8	16.6	15.3	66.4	66.4	69.3	68.4
Health & Human Services	20.5	17.9	19.1	16.6	17.6	15.3	25.1	22.1	26.1	22.5
National Institutes of Health	19.0	16.4	18.7	16.2	17.2	14.9	24.8	21.8	25.4	21.8
Interior	10.7	4.4	10.7	4.4	10.2	3.7	7.3	5.3	6.4	4.4
Geological Survey	5.3	4.4	4.7	3.8	4.0	3.2	5.0	4.0	3.7	2.9
National Aeronautics & Space Administration	37.2	1.7	33.9	1.6	8.9	1.0	11.3	1.1	12.3	1.5
National Science Foundation	7.1	3.0	6.9	3.0	6.0	2.8	2.2	0.9	4.7	2.3
Others	11.1	2.0	5.7	2.5	5.8	1.8	2.4	0.4	3.5	1.6
TOTAL	$1447.4	$161.3	$1295.0	$151.3	$1106.5	$169.2	$895.6	$188.7	$780.0	$197.6

a Estimated. b Agricultural R&D in Science & Education Administration. c Cooperative R&D in Science & Education Administration. d Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. **Note:** Fiscal years. **Source:** National Science Foundation

OBLIGATIONS FOR ENGINEERING RESEARCH: Only about 3% goes for chem engineering

	Federal obligations ($ millions)									
	1984[a]		1983[a]		1982		1981		1980	
Department or agency	Engineering	Chemical engineering	Engineering	Chemical engineering	Engineering	Chemical engineering	Engineering	Chemical engineering	Engineering	Chemical engineering
Agriculture	$ 53.0	$ 6.0	$ 53.9	$ 6.0	$ 51.2	$ 5.8	$ 50.7	$ 5.3	$ 46.5	$ 4.5
Agricultural Research Service	33.1	3.3	33.0	3.2	30.0	2.9	30.0	2.7	28.5[b]	2.4[b]
Cooperative State Research Service	6.9	0	7.5	0	6.9	0	6.3	0	5.8[c]	0[c]
Commerce	29.0	1.3	37.5	1.1	32.0	2.0	28.5	1.0	40.6	0.7
National Bureau of Standards	23.3	1.3	30.3	1.1	23.8	2.0	19.7	1.0	18.9	0.7
Defense	1618.1	42.7	1481.1	42.7	1473.3	39.0	1324.1	31.1	1165.2	24.0
Air Force	433.7	3.0	398.0	2.8	387.3	2.9	388.3	2.6	343.5	2.6
Army	353.3	26.9	292.8	27.3	297.2	24.4	266.0	18.3	231.3	10.7
Navy	421.3	12.3	389.9	12.1	378.0	11.6	356.4	9.9	314.2	10.4
Defense agencies[d]	409.8	0.4	400.4	0.5	410.8	0.2	313.4	0.2	276.2	0.4
Energy	309.5	17.9	477.0	50.1	420.8	1.1	270.2	30.6	193.1	14.4
Environmental Protection Agency	27.8	10.6	46.9	16.5	76.4	26.0	77.2	55.8	85.3	32.0
Health & Human Services	46.6	0	45.6	0	41.4	0	48.8	0	43.2	0
National Institutes of Health	46.6	0	45.6	0	41.4	0	43.6	0	43.1	0
Interior	64.1	3.7	98.3	1.1	87.1	1.4	68.5	3.4	79.1	4.2
Geological Survey	3.9	3.2	5.9	0	8.2	0.2	7.0	0	8.9	0
National Aeronautics & Space Administration	870.1	0.4	819.3	0.4	771.7	0.4	780.7	0.3	799.6	0.2
National Science Foundation	167.6	24.9	139.5	20.5	129.9	18.8	121.0	19.1	106.8	15.0
Tennessee Valley Authority	4.2	0	7.4	0	5.1	0	7.6	0	8.9	0
Others	296.9	0.4	295.0	0.5	297.6	0.6	294.2	1.0	261.7	1.3
TOTAL	$3486.9	$107.9	$3501.5	$138.9	$3386.5	$95.1	$3071.5	$147.6	$2830.1	$96.3

a Estimated. **b** Agricultural R&D in Science & Education Administration. **c** Cooperative R&D in Science & Education Administration. **d** Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, Defense Communications Agency, and others. **Note:** Fiscal years. **Source:** National Science Foundation

UNIVERSITY RESEARCH: More than 70% of federal money funneled to life, physical sciences

								Annual change	
Federal obligations, $ millions	1984[a]	1983[a]	1982	1981	1980	1979	1978	1983-84	1978-84
Engineering	$ 446.7	$ 389.3	$ 361.5	$ 365.3	$ 323.7	$ 269.6	$ 240.9	15%	11%
Chemical	25.9	21.5	19.4	21.9	20.3	19.2	24.5	20	1
Metallurgy and materials	94.6	80.6	75.3	69.5	57.3	52.3	49.2	17	12
Environmental sciences	332.3	294.8	274.7	280.3	297.0	275.5	226.5	13	7
Life sciences	2506.4	2422.1	2205.0	2117.2	1984.7	1796.0	1605.2	3	8
Mathematics and computer sciences	204.2	166.2	139.7	121.4	94.6	87.5	79.5	23	17
Physical sciences	680.1	604.2	559.1	525.2	461.0	402.8	366.6	13	11
Chemistry	220.5	204.8	189.6	193.5	159.5	140.1	123.5	8	10
Physics	386.0	338.5	306.0	274.5	246.1	214.7	198.7	14	12
Other sciences	301.3	299.0	255.7	297.5	302.7	285.6	253.0	1	3
TOTAL	$4471.0	$4175.6	$3795.7	$3706.9	$3463.6	$3117.0	$2771.7	7%	8%

a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

UNIVERSITY BASIC RESEARCH: Federal funding devoted to chemistry rises

								Annual change	
Federal obligations, $ millions	1984[a]	1983[a]	1982	1981	1980	1979	1978	1983-84	1978-84
Engineering	$ 333.4	$ 277.9	$ 259.0	$ 237.3	$ 208.4	$ 164.0	$ 151.5	20%	14%
Chemical	22.8	18.6	16.8	19.8	16.9	12.5	9.3	23	16
Metallurgy and materials	87.4	74.3	69.6	62.6	51.9	47.6	43.4	18	12
Environmental sciences	300.8	273.2	256.0	241.6	255.3	229.9	191.8	10	8
Life sciences	1728.0	1649.3	1483.7	1314.6	1219.5	1140.1	926.9	5	11
Mathematics and computer sciences	171.4	139.8	118.8	102.6	79.8	69.0	65.3	23	17
Physical sciences	579.1	496.0	455.3	434.7	375.9	323.3	299.5	17	12
Chemistry	197.6	176.8	165.3	164.7	136.1	114.3	102.2	12	12
Physics	314.8	267.5	238.6	222.4	194.3	166.2	157.1	18	12
Other sciences	159.8	151.9	120.5	148.2	152.4	125.4	103.1	5	8
TOTAL	$3272.5	$2988.1	$2693.3	$2479.0	$2291.3	$2051.7	$1738.1	10%	11%

a Estimated. **Note:** Fiscal years. **Source.** National Science Foundation

SCIENTISTS AND ENGINEERS BY AGENCY: Most chemists work for defense or health

Department or agency	Physical scientists	Chemists	Physicists	Engineers	Chemical engineers	Other scientists	Total scientists and engineers
Agriculture	1,546	902	28	3,162	56	25,554	30,262
Commerce	3,741	320	540	748	29	4,225	8,714
Defense	9,057	2097	3188	63,926	960	34,665	107,648
Air Force	1,115	312	468	11,287	63	5,842	18,244
Army	3,216	921	807	22,794	530	12,321	38,331
Navy	3,982	762	1886	28,400	359	9,992	42,374
Others	744	102	27	1,445	8	6,510	8,699
Energy	761	202	117	2,706	150	874	4,341
Environmental Protection Agency	1,574	558	15	1,561	128	1,142	4,277
Health & Human Services	2,219	2063	88	442	18	7,034	9,695
Interior	4,874	427	52	3,172	85	7,769	15,815
National Aeronautics & Space Administration	1,231	64	257	9,060	39	935	11,226
Transportation	99	25	8	4,483	13	1,529	6,111
Veterans Administration	635	557	41	1,107	0	3,354	5,096
Others	1,317	461	48	3,883	42	10,506	15,706
TOTAL	27,054	7676	4382	94,250	1520	97,587	218,891

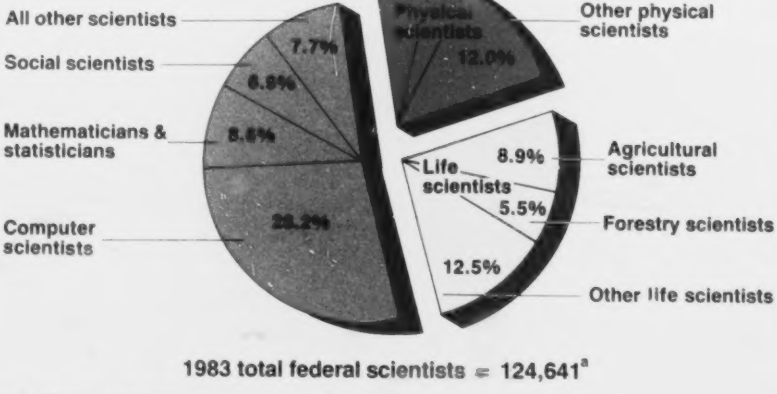
Note: Data as of October 1983 **Source:** National Science Foundation

FEDERAL SCIENTISTS AND ENGINEERS: Number of chemists has dwindled in past four years

Thousands	1983	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Physical scientists	27.1	27.4	27.6	27.6	27.5	27.1	27.1	26.7	26.3	26.4	27.4
Chemists	7.7	7.9	8.1	8.1	8.3	8.0	8.1	8.0	7.8	8.0	8.4
Physicists	4.4	4.5	4.6	4.9	5.0	5.1	5.3	5.4	5.5	5.6	5.8
Engineers	94.3	90.9	89.6	88.8	89.2	87.8	87.0	86.6	82.5	84.3	87.0
Chemical	1.5	1.4	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.5	1.6
Computer scientists	35.2	na	na	na	na	na	na	na	na	na	na
Other scientists	62.3	59.3	60.8	58.3	57.2	54.3	51.6	50.6	48.8	48.4	50.1
TOTAL	218.9	177.5	178.0	174.7	173.9	169.2	165.7	163.9	157.6	159.1	164.5

Note. As of October of each year No data for 1982 **na** = not available **Source:** National Science Foundation

Chemists constitute about 6% of all federal scientists



1983 total federal scientists = 124,641[a]

[a] As of October 1983. **Source:** National Science Foundation

Growth slows a bit for industrial R&D

In the wake of recession, spending by industrial companies expanded last year at the slowest rate in the past eight years but did well, nonetheless, in real terms

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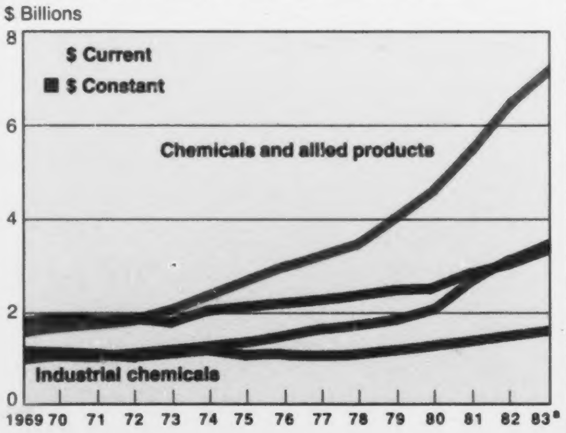
TOTAL FUNDS FOR INDUSTRIAL R&D: **Spending by chemical industry has doubled since 1978**

												Annual change	
$ Millions	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1982–83	1973–83
Chemicals and allied products	$ 7,400[a]	$ 6,588	$ 5,625	$ 4,636	$ 4,038	$ 3,580	$ 3,202	$ 3,017	$ 2,727	$ 2,450	$ 2,116	12%	13%
Industrial chemicals	3,485[a]	3,191	2,802	2,197	1,962	1,798	1,668	1,524	1,391	1,299	1,119	9	12
Drugs	3,915[a]	3,397	2,823	1,777	1,517	1,308	1,117	1,091	981	807	698	15	15
Other chemicals				662	559	474	417	401	354	344	299		
Other industries	57,200[a]	52,372	46,185	39,669	34,188	29,724	26,623	23,980	21,460	20,437	19,133	9	12
TOTAL	$64,600	$58,960	$51,810	$44,505	$38,226	$33,304	$29,825	$26,997	$24,187	$22,887	$21,249	10%	12%

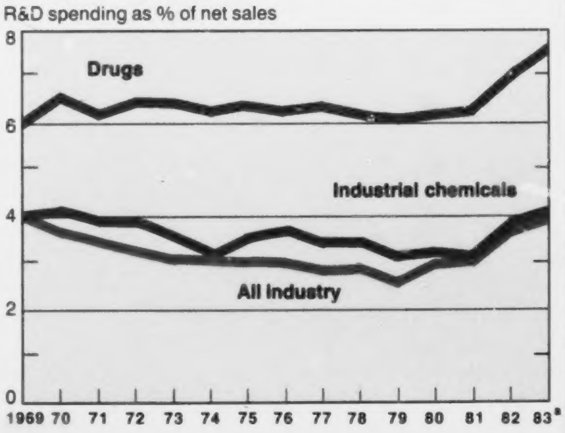
a C&EN estimates. **Source:** National Science Foundation

Increases in chemical firms' R&D budgets more than match inflation's inroads



a C&EN estimates. **Source:** National Science Foundation

Industry's spending for R&D has been rising recently relative to sales



a C&EN estimates. **Source:** National Science Foundation

FEDERAL FUNDS FOR INDUSTRIAL R&D: Chemical industry's share is only 2% of total

$ Millions	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	Annual change 1982–83	Annual change 1973–83
Chemicals and allied products	$ 475[a]	$ 433	$ 421	$ 372	$ 346	$ 330	$ 295	$ 266	$ 236	$ 214	$ 203	10%	9%
Industrial chemicals	460[a]	422	409	341	345	325	281	249	218	194	183	9	10
Drugs and other chemicals	15[a]	11	12	31	1	5	14	17	18	20	20	36	−3
Other industries	20,425[a]	18,626	15,961	13,657	12,172	10,859	10,190	9295	8369	8006	7942	10	10
TOTAL	$28,900	$19,059	$16,382	$14,025	$12,518	$11,189	$10,485	$9561	$8605	$8220	$8145	10%	10%

a C&EN estimates. **Source:** National Science Foundation

COMPANY FUNDS FOR INDUSTRIAL R&D: Drug producers' budgets rise sharply

$ Millions	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	Annual change 1982–83	Annual change 1973–83
Chemicals and allied products	$ 6,925[a]	$ 6,155	$ 5,205	$ 4,264	$ 3,692	$ 3,250	$ 2,907	$ 2,751	$ 2,490	$ 2,236	$ 1,919	13%	14%
Industrial chemicals	3,025[a]	2,769	2,393	1,856	1,617	1,473	1,387	1,275	1,173	1,105	936	9	12
Drugs	2,950[a]	2,531	2,065	1,755	2,075	1,777	1,520	1,476	1,317	1,131	977	17	15
Other chemicals	950[a]	855	747	653								11	
Other industries	$36,775[a]	33,746	30,223	26,212	22,016	18,865	16,433	14,685	13,092	12,431	11,191	9	13
TOTAL	$43,700	$39,901	$35,428	$30,476	$25,708	$22,115	$19,340	$17,436	$15,582	$14,667	$13,104	10%	13%

a C&EN estimates. **Source:** National Science Foundation

R&D BY U.S. COMPANIES ABROAD: Growth slows for spending outside U.S.

$ Millions	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	Annual change 1982–83	Annual change 1974–83
Chemicals and allied products	$ 725	$ 713	$ 715	$ 603	$ 500	$ 395	$ 332	$ 312	$ 269	$ 208	2%	15%
Industrial and other chemicals	325	313	287	245	199	151	133	108	85	82	4	17
Drugs	400	400	428	357	301	244	199	204	184	126	0	14
Other industries	2525	2400	2679	2562	2254	1814	1545	1347	1185	1092	5	10
TOTAL	$3250	$3113	$3393	$3165	$2754	$2209	$1877	$1659	$1454	$1300	4%	11%

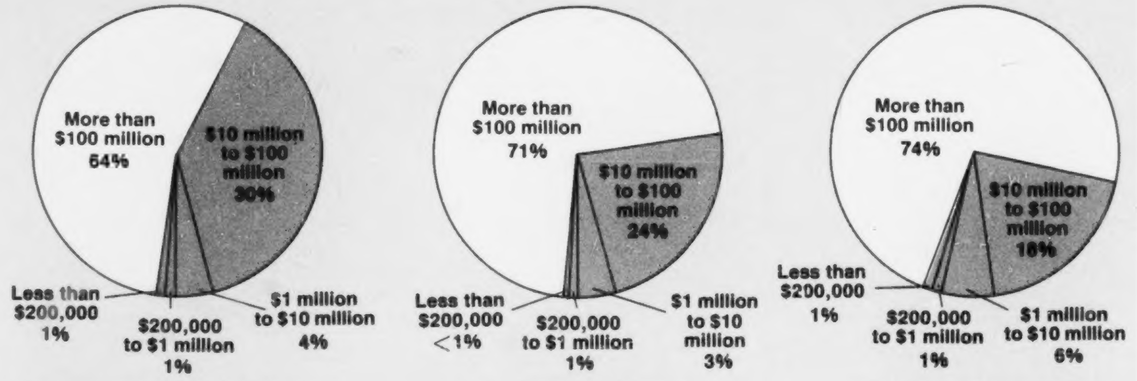
a C&EN estimates. **Source:** National Science Foundation

CHEMICAL R&D SPENDING: Increases during past two years are less than those in early 1980s

$ Millions	1984[a]	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Air Products	$ 42	$ 40	$ 37	$ 32	$ 30	$ 24	$ 23	$ 24	$ 19	$ 16	$ 11
American Cyanamid	235	215	190	172	148	130	108	96	83	73	64
Celanese	100	88	102	104	94	92	83	77	70	64	58
Dow Chemical	508	492	460	404	314	269	232	203	188	167	149
Du Pont	945	875	775	647	591	509	461	367	353	336	344
Ethyl	39	39	39	37	34	29	25	28	25	19	25
W. R. Grace	82	71	62	55	45	42	37	32	28	30	32
Hercules	66	74	74	65	57	50	43	40	37	32	32
Lubrizol	38	37	36	33	28	23	21	19	17	17	15
Monsanto	385	290	264	233	208	161	136	132	114	116	87
Olin	55	51	47	39	31	26	25	25	23	24	19
PPG Industries	125	127	127	119	103	83	70	61	56	50	47
Rohm & Haas	100	100	92	77	67	54	49	45	43	45	39
Stauffer Chemical	66	63	57	49	44	35	32	32	28	23	20
Union Carbide	250	245	240	207	166	161	156	156	143	120	94
TOTAL	$3036	$2807	$2602	$2273	$1960	$1688	$1501	$1337	$1227	$1132	$1036
ANNUAL CHANGE	8%	8%	14%	16%	16%	12%	12%	9%	8%	9%	21%

a Planned. **Source:** Company data

Firms with R&D budgets of more than $100 million do more than 60% of R&D



Total 1982 chemicals and allied products R&D funds = $6.6 billion

Total 1982 industrial chemicals R&D funds = $3.2 billion

Total 1982 industry R&D funds = $59.0 billion

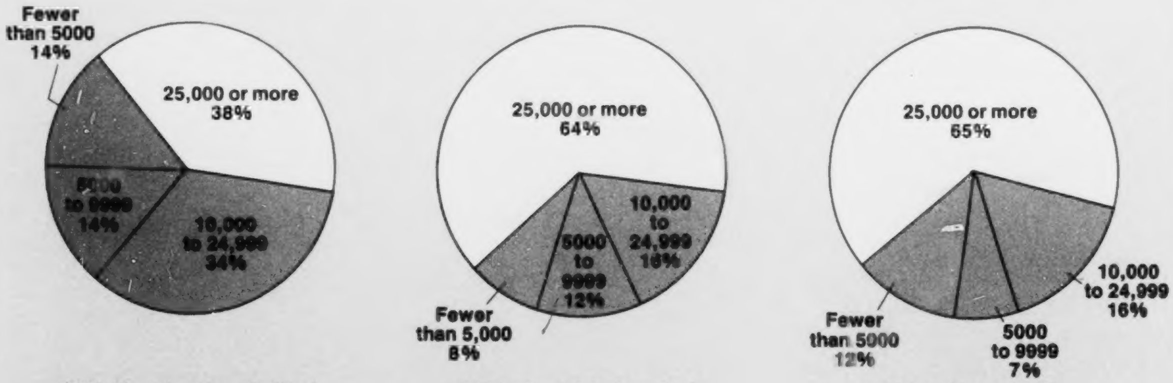
Note: Ranges indicate size of company's 1982 R&D program. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS IN INDUSTRY: Drug firms' increase boosts chemical total

Thousands[a]	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
Chemicals and allied products	**67.1**	**61.6**	**54.7**	**51.4**	**50.0**	**48.3**	**46.4**	**44.4**	**45.2**	**41.8**	**40.9**
Industrial chemicals	26.4	25.9	21.6	20.9	21.4	21.3	20.6	20.1	21.1	19.1	19.1
Drugs	30.0	25.6	23.3	21.6	20.9	19.5	17.8	16.6	15.6	14.0	13.0
Other chemicals	10.7	10.1	9.8	8.9	7.9	7.5	8.0	7.8	8.5	8.7	8.8
Other industries	**468.5**	**448.2**	**433.1**	**399.2**	**373.9**	**356.1**	**336.4**	**320.0**	**318.1**	**318.2**	**316.8**
TOTAL	**535.6**	**509.8**	**487.8**	**450.6**	**423.9**	**404.4**	**382.8**	**364.4**	**363.3**	**360.0**	**357.7**

[a] Full-time equivalent. **Note:** Data as of January of each year **Source:** National Science Foundation

Companies with the most employees account for the greatest share of R&D outlays



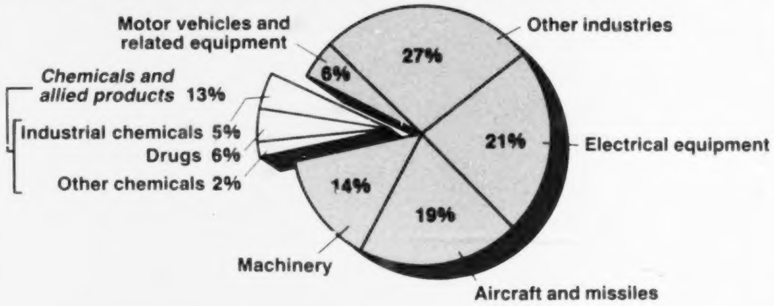
1982 chemicals and allied products R&D funds = $6.2 billion[a]

1982 industrial chemicals R&D funds = $2.8 billion[a]

1982 industry R&D funds = $39.9 billion[a]

[a] Excludes federal funding. **Note:** Ranges indicate company's number of employees in 1982. **Source:** National Science Foundation

Chemical and allied products industry employs 13% of all scientists and engineers doing industrial R&D



1983 total industrial R&D scientists and engineers[a] = 535,600

a Full-time equivalent. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS PER 1000 EMPLOYEES: Chemical firms above average

	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Chemicals and allied products	**50**	**44**	**42**	**42**	**43**	**42**	**40**	**41**	**40**	**39**	**39**	**41**
Industrial chemicals	43	37	36	36	38	38	36	38	37	36	34	35
Drugs	76	66	60	62	65	62	64	59	57	57	60	65
Other chemicals	35	33	30	27	27	29	28	29	30	29	31	31
All industry	**32**	**29**	**27**	**27**	**27**	**27**	**27**	**26**	**25**	**24**	**24**	**26**

Source: National Science Foundation

COST PER INDUSTRIAL R&D SCIENTIST OR ENGINEER: Average doubled since 1972

$ Thousands	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Chemical and allied products	**$102.4**	**$ 96.6**	**$ 87.4**	**$79.6**	**$72.8**	**$67.6**	**$66.5**	**$60.9**	**$56.3**	**$51.1**	**$47.1**
Industrial chemicals	122.0	118.0	103.4	92.8	84.2	79.6	74.7	67.5	63.5	58.6	54.0
Drugs	a	a	79.2	71.4	64.8	59.9	63.4	60.9	54.3	51.5	46.5
Other chemicals	a	a	66.5	66.5	61.6	53.8	50.8	43.2	45.3	34.0	33.4
All industry	**$112.8**	**$103.9**	**$ 94.9**	**$87.4**	**$80.4**	**$75.8**	**$72.2**	**$66.5**	**$63.3**	**$59.2**	**$55.3**

a Not separately available but included in chemicals and allied products. **Source:** National Science Foundation

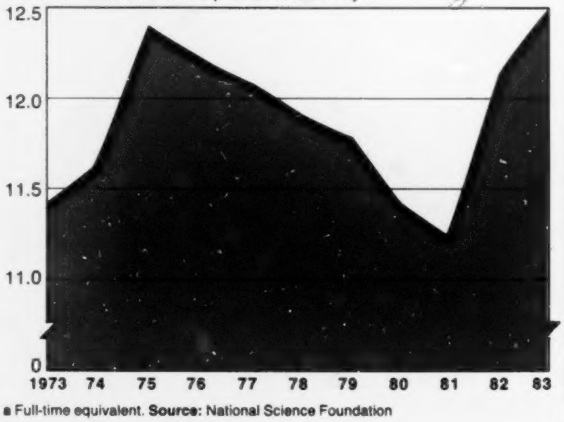
CHEMISTS IN INDUSTRY: Nearly 40% of Ph.D.s work for chemical firms

	% of industrial chemists			
Industry	**All chemists**	**B.S.**	**M.S.**	**Ph.D.**
Chemical	34%	29%	31%	39%
Pharmaceutical[a]	18	16	19	18
Petroleum	6	5	5	7
Coatings	5	7	6	3
Food	4	4	4	4
Metals and minerals	3	4	3	2
Rubber	2	3	3	2
Other manufacturing	21	22	22	21
Nonmanufacturing	7	10	8	5

a Includes personal care products. **Source:** 1984 ACS survey

Share of R&D scientists and engineers in chemical industry climbs to 10-year peak

% of total industrial R&D scientists and engineers in the chemicals and allied products industry[a]



a Full-time equivalent. **Source:** National Science Foundation

4 R&D

Universities and Colleges

Growth in federal support slackens

Government funds pay for nearly two thirds of R&D on U.S. campuses, but industry's still small share is expanding fast

CHARACTER OF UNIVERSITY R&D SPENDING: Two thirds goes to basic research

												Annual change	
$ Millions	1983[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1983-82	1973-83
Basic research	$5135	$4851	$4576	$4020	$3612	$3176	$2800	$2549	$2410	$2154	$2053	6%	10%
Applied research	2095	1995	1865	1691	1465	1213	1067	1015	851	736	713	5	11
Development	445	415	377	343	284	236	200	164	148	133	118	7	14
TOTAL	**$7675**	**$7261**	**$6818**	**$6060**	**$5361**	**$4625**	**$4067**	**$3728**	**$3409**	**$3023**	**$2884**	**6%**	**10%**

a Estimated. **Source:** National Science Foundation

SOURCE OF UNIVERSITY R&D FUNDS: Industry's share is small but growing fastest

												Annual change	
$ Millions	1983[a]	1982	1981	1980	1979	1978[b]	1977	1976	1975	1974	1973	1982-83	1973-83
Federal government	$4900	$4749	$4559	$4094	$3595	$3059	$2726	$2512	$2288	$2032	$1985	3%	9%
State and local governments	650	586	540	494	470	414	374	364	332	307	295	11	8
Industry	375	326	288	236	193	170	139	123	113	96	94	15	16
Institutional funds	1210	1098	983	829	730	623	514	446	417	370	318	10	14
Other sources	540	503	448	409	374	359	314	285	259	218	202	7	10
TOTAL	**$7675**	**$7261**	**$6818**	**$6060**	**$5631**	**$4625**	**$4067**	**$3729**	**$3409**	**$3023**	**$2884**	**6%**	**10%**

a Estimated. b Estimated, based on data from Ph.D.-granting institutions only. **Note:** Data for institutional fiscal year. **Source:** National Science Foundation

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FIELDS OF UNIVERSITY R&D SPENDING: Chemistry shows better than average growth

												Annual change	
$ Millions	1983[a]	1982	1981	1980	1979	1978[b]	1977	1976	1975	1974	1973	1982-83	1973-83
Physical sciences	**$1880**	**$ 822.8**	**$ 766.5**	**$ 677.6**	**$ 601.9**	**$ 496.4**	**$ 423.5**	**$ 379.4**	**$ 350.3**	**$ 333.5**	**$ 328.3**	7%	10%
Chemistry	335	311.5	285.5	244.5	206.4	183.1	159.4	140.1	120.7	115.8	113.7	8	11
Physics	385	363.3	356.9	322.1	292.0	235.1	201.7	183.1	173.5	169.3	167.0	6	9
Engineering	**1080**	**1024.5**	**960.0**	**864.0**	**768.4**	**601.1**	**498.5**	**431.7**	**380.9**	**346.9**	**333.1**	5	12
Total R&D spending	**$7675**	**$7260.6**	**$6818.3**	**$6060.1**	**$5361.4**	**$4624.7**	**$4067.0**	**$3729.0**	**$3408.7**	**$3022.6**	**$2884.0**	6%	10%

a C&EN estimates. b NSF estimates, based on data from Ph.D.-granting institutions only. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

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FEDERALLY FINANCED R&D SPENDING AT UNIVERSITIES: Increases were modest last year

												Annual change	
$ Millions	1983[a]	1982	1981	1980	1979	1978[b]	1977	1976	1975	1974	1973	1982-83	1973-83
Physical sciences	**$ 675**	**$ 649.7**	**$618.6**	**$ 554.5**	**$ 490.7**	**$ 392.3**	**$ 338.8**	**$ 305.4**	**$ 285.0**	**$ 270.2**	**$ 268.4**	4%	10%
Chemistry	245	231.6	216.6	189.3	156.5	138.0	121.5	107.9	92.7	88.7	86.6	6	11
Physics	310	305.9	308.5	279.7	252.5	199.2	171.9	156.1	149.9	146.5	145.4	1	8
Engineering	**710**	**697.2**	**661.6**	**594.6**	**526.4**	**407.5**	**336.7**	**290.5**	**259.4**	**239.3**	**238.1**	2	12
Total R&D spending	**$4900**	**$4749.3**	**$4559.0**	**$4093.6**	**$3595.3**	**$3058.7**	**$2726.1**	**$2511.9**	**$2288.1**	**$2032.2**	**$1985.4**	3%	9%

a C&EN estimates. b NSF estimates, based on data from Ph.D.-granting institutions only. **Note.** Data for institutional fiscal years. **Source:** National Science Foundation

TOP 12 UNIVERSITIES IN R&D SPENDING: Johns Hopkins, MIT lead in science and engineering

$ Millions, fiscal 1982	Physical sciences	Chemistry[a]	Engineering	Environmental sciences	Life sciences	Math and computer sciences	Other sciences[b]	Total
Johns Hopkins U	$53.9	$4.7	$76.4	$29.3	$73.8	$46.3	$10.2	**$289.9**
Massachusetts Inst. of Technology	49.1	9.8	84.1	12.0	26.2	8.8	12.3	**192.5**
U of Wisconsin, Madison	14.5	4.6	15.9	13.8	85.7	5.9	21.8	**157.6**
Stanford U	23.1	6.6	45.1	3.2	60.4	10.2	5.9	**147.9**
U of Minnesota	9.1	4.3	12.8	2.6	110.7	1.8	9.5	**146.5**
Cornell U	23.8[c]	6.2[c]	22.6[c]	4.1[c]	83.3[c]	2.6[c]	9.4[c]	**145.8**
U of California, San Diego	17.8	3.9	1.0	61.3	54.0	1.9	2.9	**138.9**
U of Washington	8.1	2.3	7.6	15.3	80.2	2.0	19.9[c]	**133.1**
U of Michigan	8.0	2.1	17.4	6.0	58.7	2.4	27.5	**120.0**
Columbia U, main division	11.6	4.7	6.4	22.3	68.2	0.8	6.3	**115.6**
Harvard U	14.2[c]	5.5[c]	1.7[c]	6.6[c]	81.5[c]	1.5[c]	9.3[c]	**114.8[c]**
U of Pennsylvania	9.2	3.1	6.6	0.7	72.2	3.1	21.0	**112.8**

a Included in physical sciences. b Includes social sciences, psychology, and other sciences not listed separately. c Estimated. **Source:** National Science Foundation

TOP 12 UNIVERSITY R&D CENTERS:[a] Half of funding spent on physical sciences

$ Millions, fiscal 1981	Physical sciences	Engineering	Environmental sciences	Math and computer sciences	Total[b]
Los Alamos Natl Lab	$237.7	$159.6	$10.4	$ 43.3	**$497.3**
Lawrence Livermore Natl Lab	377.7	47.3	30.2	11.5	**487.4**
Jet Propulsion Lab	70.0	158.8	23.6	140.7	**393.1**
Argonne Natl Lab	65.9	113.9	34.9	2.8	**230.5**
Brookhaven Natl Lab	106.6	30.1	9.0	0.4	**168.4**
Lincoln Lab	30.0	108.7	0	15.9	**154.8**
Lawrence Berkeley Lab	76.0	12.1	12.9	4.0	**128.2**
Plasma Physics Lab	115.6	0	0	0	**115.6**
Fermi Natl Accelerator Lab	108.7	0	0	0	**108.7**
Stanford Linear Accelerator Center	70.7	0	0	0	**70.7**
National Center for Atmospheric Research	3.9	0	35.2	0	**39.1**
Ames Laboratory	12.4	5.5	0	0.5	**18.5**

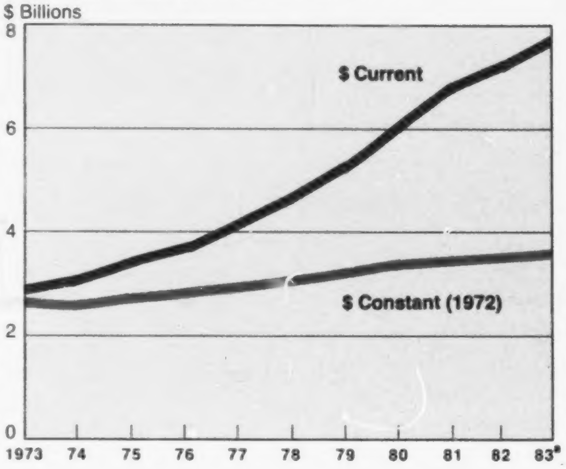
a Data for university-administered federally funded R&D centers. b Includes life sciences and other sciences not listed separately. **Source:** National Science Foundation

ACADEMIC SCIENTISTS AND ENGINEERS: Little change for chemists since 1981

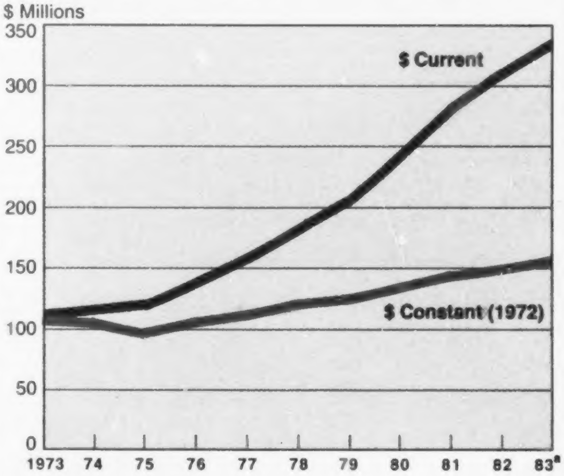
Thousands of scientists and engineers[a]	1983	1982	1981	1980	1978	1977	1976
TOTAL							
Physical scientists	**34.7**	**34.5**	**34.1**	**33.6**	**32.8**	**32.1**	**31.4**
Chemists	18.2	18.0	18.1	17.6	17.7	17.1	16.6
Physicists	13.5	13.3	12.9	13.0	12.8	12.5	12.2
Engineers	**37.7**	**36.4**	**34.8**	**33.7**	**31.0**	**30.1**	**28.5**
Chemical	2.4	2.3	2.3	2.4	2.0	1.9	1.9
Other scientists	**286.4**	**278.4**	**265.6**	**257.0**	**243.9**	**235.7**	**228.4**
TOTAL	**358.8**	**349.3**	**334.5**	**324.2**	**307.8**	**297.9**	**288.3**
FULL TIME ONLY							
Physical scientists	**28.4**	**28.5**	**28.2**	**28.0**	**27.9**	**27.6**	**27.1**
Chemists	14.7	14.4	14.8	14.3	14.7	14.5	14.1
Physicists	11.4	11.4	11.0	11.3	11.3	11.1	10.8
Engineers	**28.8**	**28.0**	**27.0**	**26.5**	**24.7**	**24.1**	**22.9**
Chemical	2.0	1.9	1.9	1.9	1.7	1.7	1.6
Other scientists	**215.8**	**211.3**	**204.6**	**200.5**	**189.5**	**184.6**	**179.9**
TOTAL	**273.0**	**267.8**	**259.7**	**255.0**	**242.2**	**236.3**	**229.9**

a In January. **Note:** Data not available for 1979. **Source:** National Science Foundation

Spending for all academic R&D is barely holding steady in real terms . . .



. . . and chemical R&D spending also is struggling to keep pace with inflation



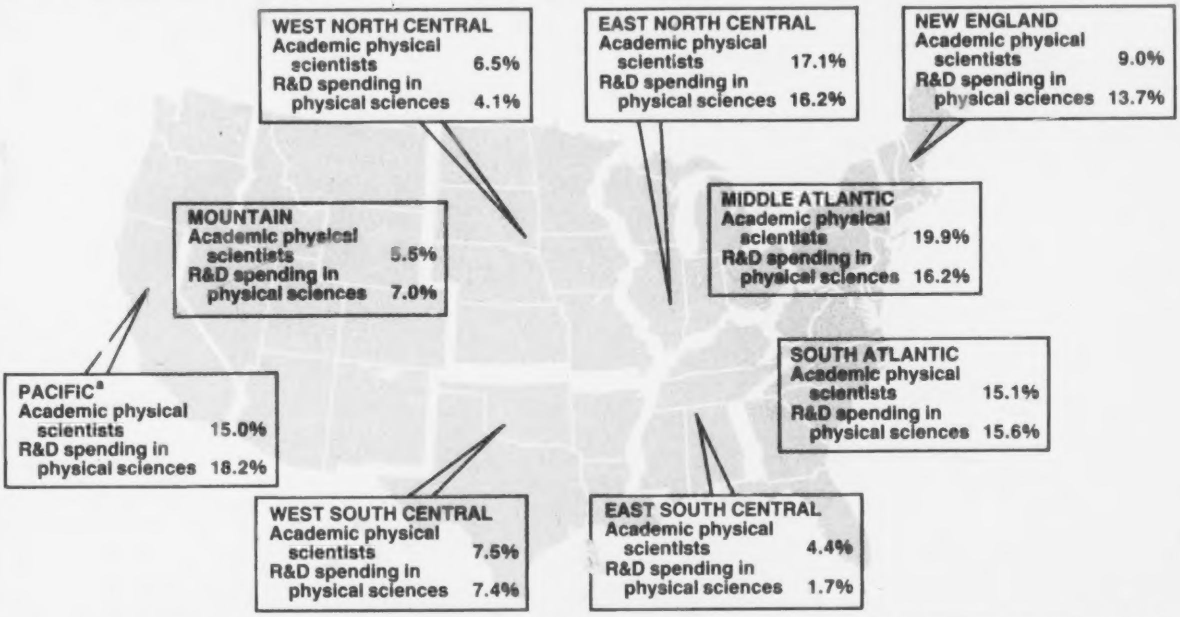
a C&EN estimate. **Note:** Data for institutional fiscal years.
Source: National Science Foundation

SCHOOLS SPENDING MOST ON CHEMICAL R&D: Top 50 spent over 60% of total

$ Thousands	Total spending 1982	1981	1980	1979	Federally financed spending 1982	1981	1980	1979
1 Massachusetts Inst. of Technology	$ 9,792	$ 8,222	$ 6,764	$ 5,324	$ 9,096	$ 7,572	$ 6,311	$ 5,021
2 Stanford U	6,634	5,564	4,788	4,159	5,893	5,337	4,609	3,775
3 U of Illinois, Urbana	6,422	5,239	4,261	3,963	4,763	3,847	3,424	2,696
4 U of California, Berkeley	6,283	6,553	6,022	3,717	5,691	6,008	5,601	3,485
5 Cornell U	6,239[a]	4,618	3,808	3,414	5,437	4,602	3,404	3,087
6 California Inst. of Technology	6,136	6,901	6,328	5,297	5,809	6,196[a]	5,630	4,813
7 Harvard U	5,512[a]	6,123[a]	4,797[a]	4,283[a]	4,174	4,637	3,631	3,241
8 Indiana U	5,341	3,637	3,147	2,644	4,237	3,042	2,635	2,306
9 U of California, Los Angeles	5,187	4,420	4,159	3,573	4,978	4,127	4,017	3,379
10 U of Texas, Austin	4,843	4,779	3,970	3,373	2,781	3,017	2,564	2,282
Total, first 10 institutions	**62,389**	**56,056**	**48,044**	**39,747**	**52,859**	**47,845**	**41,826**	**34,085**
11 Johns Hopkins U	4,721	4,066	4,652	4,064[a]	3,800	3,881	4,444	3,968[a]
12 Columbia U, main division	4,700	3,564	4,437	3,531	4,365	3,471	4,054	3,202
13 U of Wisconsin, Madison	4,567	4,122	3,976	3,346	3,404	3,134	2,944	2,353
14 Texas A&M U	4,521	4,069	4,097	3,715	2,823	2,793	2,945	2,361
15 Purdue U	4,459	4,600	3,596	3,438	3,946	3,715	3,151	3,087
16 U of Chicago	4,396[a]	4,139[a]	3,958[a]	3,418[a]	3,716	3,719	3,558	3,039
17 U of Massachusetts, Amherst	4,364	3,230	1,889	2,621	2,773	2,067	1,632	1,921
18 U of Minnesota	4,297	4,260	2,642	2,162	3,377	2,494	2,143	1,624
19 U of Notre Dame	4,020	3,855	3,457	2,746	3,866	3,738	3,328	2,618
20 U of Maryland, College Park	4,009	3,109	2,766	1,907	3,068	2,418	2,292	1,628
Total, first 20 institutions	**106,443**	**95,070**	**83,514**	**70,695**	**87,997**	**80,275**	**72,317**	**59,886**
21 U of California, San Diego	3,894	4,430	4,425[a]	3,757[a]	3,506	3,933	4,375[a]	3,707[a]
22 Pennsylvania State U	3,564	3,413	2,973	2,303	3,222	2,773	2,527	1,989
23 U of Colorado	3,492	4,047	3,332	2,544	2,755	3,146	2,605	1,942
24 U of Utah	3,364	3,076	2,811	2,290	2,858	2,720	2,373	1,949
25 Georgia Inst. of Technology	3,327	3,660	3,655	3,577	1,800	2,030	2,118	2,110
26 U of Nebraska, Lincoln	3,217	2,175	2,289	1,745	1,995	1,757	1,909	983
27 U of Rochester	3,123	2,966	2,089	2,536	2,774	2,553	1,667	2,056
28 U of Pennsylvania	3,068	3 386	3,688	2,211	2,745	3,073	3,143	1,840
29 Princeton U	3,062	2,513	2,065	2,242	2,485	2,142	1,646	1,621
30 Northwestern U	3,026	2,995	2,367	1,851	2,711	2,813	2,221	1,671
Total, first 30 institutions	**139,580**	**127,731**	**113,208**	**95,751**	**114,848**	**107,215**	**96,901**	**79,754**
31 Rensselaer Polytech Inst.	2,975	2,286	1,551	968	1,724	1,310[a]	962	680[a]
32 U of Oregon, main	2,971	1,389	1,119	1,074	2,530	1,235	1,035	889
33 Florida State U	2,959	3,012	2,791	2,478	1,124	1,463	1,313	1,160
34 Ohio State U	2,907	3,227	2,654	2,039	2,355	2,679	2,144	1,743
35 Yale U	2,875	2,781	2,023	2,107	2,599	2,609[a]	1,886	1,750
36 Syracuse U	2,868	2,259	764	697[a]	1,278	551	396	327
37 State U of New York, Stony Brook	2,783	2,691	1,966	1,801	1,901	2,080	1,632	1,554
38 U of Pittsburgh	2,714	2,039	1,641	1,728	2,188	1,581	1,366	1,416
39 Wayne State U	2,656	2,261	2,163	2,022	1,799	1,636	1,640	1,555
40 Lehigh U	2,584	1,680	1,066	787	1,189	1,063	480	248
Total, first 40 institutions	**167,872**	**151,356**	**130,946**	**111,446**	**133,535**	**123,422**	**109,755**	**91,076**
41 Michigan State U	2,493	2,178	1,638	1,491	1,832	1,541	1,157	1,045
42 U of South Carolina	2,483	1,087[b]	970[a]	933	1,865	902[b]	816[a]	785
43 Colorado State U	2,479	2,385	1,973	1,774	2,230	2,079	1,717	1,579
44 U of Southern California	2,401	2,345	2,313	2,181	1,717	1,639	1,773	1,731
45 U of Iowa	2,331	1,822	1,488	1,185	1,195	923	807	447
46 Arizona State U	2,323	2,153	1,449	1,076	1,996	1,958	1,365	805
47 U of Oklahoma	2,306	1,399	1,275	869	1,067	674	617	441
48 U of Washington	2,276	1,500	1,326	921	1,775	1,404	1,117	828
49 U of Florida	2,248	2,302	2,283[a]	1,968	1,341	1,156	1,214[a]	1,339
50 State U of New York, Buffalo	2,242	2,203	1,665	1,143	1,528	1,626	1,163	817
TOTAL, FIRST 50 INSTITUTIONS	**$191,454**	**$170,730**	**$147,326**	**$124,987**	**$150,081**	**$137,324**	**$121,501**	**$100,893**
NATIONAL TOTAL	**$311,452**	**$285,520**	**$244,454**	**$206,421**	**$231,627**	**$216,630**	**$189,287**	**$156,516**

a Estimate. b Imputed. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

A fifth of academic physical scientists work at Mid-Atlantic schools, but West Coast schools account for biggest share of R&D outlays in physical sciences


WEST NORTH CENTRAL
Academic physical scientists 6.5%
R&D spending in physical sciences 4.1%
EAST NORTH CENTRAL
Academic physical scientists 17.1%
R&D spending in physical sciences 16.2%
NEW ENGLAND
Academic physical scientists 9.0%
R&D spending in physical sciences 13.7%
MOUNTAIN
Academic physical scientists 5.5%
R&D spending in physical sciences 7.0%
MIDDLE ATLANTIC
Academic physical scientists 19.9%
R&D spending in physical sciences 16.2%
SOUTH ATLANTIC
Academic physical scientists 15.1%
R&D spending in physical sciences 15.6%
PACIFIC[a]
Academic physical scientists 15.0%
R&D spending in physical sciences 18.2%
WEST SOUTH CENTRAL
Academic physical scientists 7.5%
R&D spending in physical sciences 7.4%
EAST SOUTH CENTRAL
Academic physical scientists 4.4%
R&D spending in physical sciences 1.7%

Key to map: Using the Middle Atlantic states as an example, 19.9% of all physical scientists employed at U.S. universities and colleges are located in this geographical area and 16.2% of all R&D expenditures in the physical sciences by universities and colleges are in this area. a Includes Alaska and Hawaii. **Note:** Data are based on 34,227 physical scientists employed at universities and colleges in the U.S. as of January 1983, and R&D expenditures of $821.5 million in the physical sciences during these institutions' 1982 fiscal year. Data exclude universities and colleges in outlying areas. **Source:** National Science Foundation

CHEMICAL DEGREES: B.S. degrees continue to rise for engineers, drop for chemists

Academic year	Degrees awarded in chemistry[a]			Degrees awarded in chemical engineering		
	Bachelors	Masters	Ph.D.s	Bachelors	Masters	Ph.D.s
1965-66	9,735	1839	1571	2848	994	354
1966-67	9,872	1831	1744	2869	949	305
1967-68	10,847	2014	1757	3211	1156	367
1968-69	11,807	2070	1941	3557	1136	409
1969-70	11,617	2146	2208	3720	1045	438
1970-71	11,183	2284	2160	3615	1100	406
1971-72	10,721	2259	1971	3663	1154	394
1972-73	10,226	2230	1882	3636	1051	397
1973-74	10,525	2138	1828	3454	1045	400
1974-75	10,649	2006	1824	3142	990	346
1975-76	11,107	1796	1623	3203	1031	308
1976-77	11,322	1775	1571	3581	1086	291
1977-78	11,474	1892	1525	4615	1237	259
1978-79	11,643	1765	1518	5655	1149	304
1979-80	11,446	1733	1551	6383	1271	284
1980-81	11,347	1654	1622	6527	1267	300
1981-82	11,062	1751	1722	6740	1285	311

a Does not include biochemistry and geochemistry. **Source:** Department of Education's National Center for Education Statistics

GRADUATE SCIENCE STUDENTS: 60% in physical sciences are studying chemistry

Thousands	1982	1981	1980	1979	1978	1977	1976
TOTAL							
Physical sciences	**26.5**	**25.8**	**25.4**	**24.9**	**24.7**	**24.8**	**24.8**
Chemistry	15.8	15.3	15.1	14.9	14.8	14.6	14.4
Physics	10.0	9.9	9.6	9.3	9.2	9.5	9.6
Engineering	**80.5**	**76.7**	**72.0**	**68.7**	**65.7**	**65.7**	**64.1**
Chemical	7.0	6.3	5.9	5.4	5.2	5.1	5.1
Metallurgical and materials	3.0	3.0	2.8	2.7	2.5	2.5	2.3
Petroleum	0.6	0.5	0.5	0.4	0.4	0.4	0.4
Life sciences	**42.0**	**41.8**	**42.5**	**42.5**	**43.0**	**43.0**	**41.8**
Biochemistry	4.1	4.0	3.9	3.9	4.0	3.8	3.7
Other sciences[a]	**198.4**	**195.9**	**194.0**	**184.5**	**176.4**	**173.1**	**167.5**
TOTAL	**347.4**	**340.2**	**333.9**	**320.6**	**309.8**	**306.6**	**298.2**
FULL TIME ONLY							
Physical sciences	**23.4**	**22.6**	**22.3**	**21.8**	**21.5**	**21.7**	**21.6**
Chemistry	13.8	13.2	13.1	12.8	12.7	12.6	12.4
Physics	9.0	8.8	8.5	8.3	8.2	8.5	8.5
Engineering	**49.1**	**45.2**	**42.3**	**39.7**	**37.4**	**37.0**	**36.4**
Chemical	5.5	4.9	4.4	4.2	3.9	3.8	3.7
Metallurgical and materials	2.5	2.4	2.2	2.1	2.0	1.9	1.9
Petroleum	0.5	0.4	0.4	0.3	0.3	0.3	0.3
Life sciences	**35.2**	**35.3**	**35.6**	**35.6**	**35.8**	**36.0**	**35.4**
Biochemistry	3.8	3.7	3.6	3.6	3.7	3.6	3.5
Other sciences[a]	**130.0**	**131.3**	**130.5**	**126.3**	**121.9**	**122.8**	**120.7**
TOTAL	**237.7**	**234.4**	**230.7**	**223.4**	**216.6**	**217.5**	**214.1**

a Includes environmental, mathematical, computer, health, agricultural, and social sciences and psychology. **Note:** Data for Ph.D.-granting institutions only. **Source:** National Science Foundation

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Mineral inorganics remain stagnant
A Key Chemicals Review
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Flavors & Fragrances

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JULY 30, 1984

News of the Week

- **House Superfund bill: taxes too high, says industry; too costly to implement, says EPA.** Page 4
- **Vista Chemical, successor to Conoco Chemicals, has begun operations.** Page 5
- **Daniel E. Koshland Jr. is the new editor of *Science*.** Page 5
- **Research at NIMH unearths a biochemical marker to identify persons vulnerable to manic-depressive psychoses.** Page 6
- **Fire and explosions at Union Oil's Romeoville, Ill., refinery kill 15, cause extensive damage.** Page 6

Cover: Vanillin crystal photographed with cross-polarized filters. Photo courtesy of Givaudan

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Business

Production of the large-volume mineral-based inorganics remains below prerecession levels output of lime and sulfur will be up this year, but potash and phosphorus will be flat. **Page 15**

Government

House bill would lengthen protection for products patented under FDCA to compensate for premarket review period. **Page 21**

Education

ACS-sponsored first U.S. team does well in chemistry Olympiad in West Germany, winning one silver, two bronze medals. **Page 23**

Technology

Portable chemical vapor detector being developed by Argonne National Laboratory can sniff out trace levels of contamination from a wide range of gases and vapors. **Page 26**

Science

Decamethylsamarocene, organolanthanide complex that contains only two cyclopentadienyl ligands, has been synthesized. **Page 27**

CEAN
PERF
ORNED BEE
WET DOG

News Focus

The many makers of flavors and fragrances face more mergers and acquisitions as sales growth slows and profits decline. **Page 7**

SUPERFUND REWRITE: Firms say House bill tax outrageous

As a major rewrite and expansion of the Superfund law sped toward a House vote in early August, large and small firms in the chemical industry went before the House Ways & Means Committee to plead the case that the feedstock taxes contained in the bill were so high as to be self-defeating.

The chemical industry, its witnesses emphasized, does believe that Superfund should be continued beyond its Sept. 30, 1985, expiration date. And it believes that abandoned dump sites that pose hazards to human health or the environment should be identified and cleaned up. The bill containing the Superfund rewrite, H.R. 5640, seeks to raise $9 billion over five years from industry taxes, compared to the current $1.6 billion over five years.

These amounts are "exceedingly high," says Robert D. Kennedy, Union Carbide executive vice president, and "are likely to have very serious—devastating may not be too strong a word—consequences for the basic petrochemical industry in the U.S." He points out that production of the 11 primary petrochemicals subject to the Superfund tax involved a net loss of $400 million in 1982 and barely broke even in 1983, yet also paid $158 million a year in Superfund taxes. Over the next several years, Superfund taxes, at the rate imposed in the bill, will equal 30 to 100% of the prospective earnings in primary petrochemicals, Kennedy says.

In addition to "general anguish" over the level of taxes imposed in the bill, Kennedy says, the company is concerned about the individual taxes on certain feedstocks. These, he says, do not appear to have any rational or even discernible relationships to the price of the feedstock, to its competitive situation in the marketplace, or to the hazardous products that may be the result of its production, use, or disposal. Apparently, he says, the specific tax rates for each substance on the list were developed by guessing at a 1986 sales price for each substance and setting the tax rate, in dollars per ton, at 3% of this estimated price, but not higher than $29.87 per ton for organic materials and $14.94 for inorganic materials.

But this doesn't always hold true. For example, ethylene, under H.R. 5640, would be subject to a tax of $17.71 per ton, an effective tax rate of 4.5% of its present price and 4% of the estimate of its 1986 price of $440 per ton. Yet the bill would impose a tax rate of $1.44 per ton on uranium oxide appparently, Kennedy says, based on 3% of an estimated sales price of $47.90. Although that is a very high price for uranium oxide, he points out that that is a price per pound, not a price per ton. The average current price for uranium oxide is about $38 per lb, or about $76,000 per ton. Thus, if the rationale of the drafters of the bill were uniformly applied, the tax rate for uranium oxide should be the ceiling price for inorganic substances.

The Synthetic Organic Chemical Manufacturers Association is con-

Bill would raise tax on some chemicals 500%

Tax per ton	1984	House bill
Acetylene	$4.87	$29.87
Aluminum	—	1.53
Ammonia	2.64	7.44
Antimony	4.45	14.94
Antimony trioxide	3.75	14.94
Arsenic	4.45	14.94
Arsenic trioxide	3.41	14.94
Asbestos	—	13.92
Barium sulfide	2.30	14.94
Benzene	4.87	14.88
Boron trioxide	—	14.88
Bromine	4.45	2.88
Butadiene	4.87	14.94
Butane	4.87	14.94
Butylene	4.87	24.80
Cadmium	4.45	7.09
Chlorine	2.70	9.92
Chromite	1.54	14.94
Chromium	4.45	5.67
Coal tars	—	2.55
Cobalt	4.45	14.94
Cupric oxide	3.59	10.63
Cupric sulfate	1.87	3.93
Cuprous oxide	3.97	14.94
Ethylene	4.87	14.88
Hydrochloric acid	0.29	14.88
Hydrogen fluoride	4.23	14.88
Lead oxide	4.14	17.71
Lithium carbonate	—	0.34
Manganese	—	14.94
Mercury	4.45	14.94
Methane	3.44	14.94
Naphthalene	4.87	2.77
Nickel	4.45	14.94
Nitric acid	0.24	0.28
Phosphoric acid	—	0.30
Phosphorus	4.45	14.94
Potassium dichromate	1.69	14.94
Potassium hydroxide	0.22	0.26
Propylene	4.87	13.82
Selenium	—	14.94
Sodium dichromate	1.87	14.94
Sodium hydroxide	0.28	0.33
Stannic chloride	2.12	14.94
Stannous chloride	2.85	14.94
Sulfuric acid	0.26	0.31
Toluene	4.87	12.75
Uranium oxide	—	1.44
Vanadium	—	2.48
Xylene	4.87	13.11
Zinc	—	14.94

cerned not only about the high tax rates on feedstocks to member companies but also about the new waste-end tax that would be imposed by the bill.

The waste-end tax is based on "wet-weight." This formula, says SOCMA executive director Ronald A. Lang, would treat the generator of highly concentrated toxic waste in the same fashion as a generator that has a very small quantity of such toxics in an immense volume of water. The latter in effect would be paying taxes primarily on the water. "I cannot believe," Lang says, "that this is the intent of the authors." An easy way out of this dilemma, he suggests, would be to establish a higher tax rate based on the dry weight of the hazardous materials generated.

The Chemical Manufacturers Association had some other suggestions as to how the bill could be improved. First, make a realistic determination of what EPA's annual funding needs will be. Next derive those funds from a more broadly based taxing mechanism, although CMA does support a doubling of the present industry tax rates. Provide that funding over a five-year period so the agency's needs can be re-examined. And finally, re-enact the current law unchanged in all other respects.

If the fivefold tax rate increase is allowed, CMA chairman Edwin C. Holmer, president of Exxon Chemical, warned the committee, serious consequences will result. It could eliminate or jeopardize 30,000 industry jobs, lead to the shutting down of nearly 4 billion lb of primary petrochemical capacity and jeopardize an additional 3.5 billion lb of capacity and restrict future plant investment.

Few if any changes are likely to be made in the bill by the Ways & Means Committee even if it were sympathetic to industry's pleas. Its chairman, Rep. Dan Rostenkowski (D.-Ill.), has committed himself to having the bill ready for floor action before Congress recesses for the Republican national convention on Aug. 13. There just isn't enough time to make major changes in the bill. So the chemical industry will have to take its case to the Senate. ☐

Vista Chemical starts operations

Earlier this month, Vista Chemical—the successor company to Conoco Chemicals—began operating as a new company. Vista comprises most of the assets of the Conoco unit purchased from Du Pont for about $500 million by a group of investors headed by former Conoco Chemicals executives.

According to Vista, 1983 sales of $523 million for the Conoco Chemicals businesses purchased by Vista would have placed the company about 445th on the Fortune 500, had it been a publically held company at the time. Sales of this size would have placed it 58th among C&EN's ranking of the 100 largest chemical producers in the U.S.

A privately held company with headquarters in Houston, Vista is starting with a product line similar to that of Conoco Chemicals. The company has plants at Lake Charles, La., where it makes products such as ethylene, normal paraffins, vinyl chloride, long-chain alcohols, and detergent alkylates; at Aberdeen, Miss., and Oklahoma City, Okla., where it makes polyvinyl chloride resins and compounds; and at Hammond, Ind., and Balimore, where it produces detergent alkylates and derivatives.

The company employs 1500 people worldwide. They include personnel in plants involved in the purchase by Vista and some 200 staff or chemicals support people with Conoco Inc. Du Pont purchased Conoco Inc. in the fall of 1981 for $7.8 billion.

"Over 35 former Conoco Chemicals managers are members of the Vista Chemical investment group and are actively involved in day-to-day operations of the new company," says John D. Burns, president and chief executive officer of Vista and former executive vice president of Conoco Chemicals. "We are all committed to the success of Vista Chemical and are excited about the challenge and opportunity that lie ahead," he adds.

Burns: committed to its success

Burns also says that no substantive changes are planned for Vista's operations and product lines in the near future. "Vista Chemical will direct its efforts toward operating the existing businesses as efficiently and safely as they were under Conoco," he says.

Gordon A. Cain, a former Conoco vice president who, with the E. F. Hutton Group, organized the investment team, is chairman of the board of Vista. R&D operations of the new firm will use facilities leased from Conoco in Ponca City, Okla., for several years under terms of the purchase agreement.

International operations for Vista are directed through three subsidiaries. These include Vista Chemical Co. Latin America, headquarted in Houston; Vista Chemical Co. Far East, in Tokyo; and Vista Chemical Europe, in Brussels. Vista also holds partial interests in three foreign affiliates, two in Japan, and one in Argentina. ☐

Berkeley's Koshland named *Science* editor

Daniel E. Koshland Jr., 64-year-old professor of biochemistry at the University of California, Berkeley, has been named editor of *Science*, the weekly journal of the American Association for the Advancement of Science. He will take over the position in January 1985.

Flavors and Fragrances Industry Faces Season of Consolidation

This highly fragmented industry of many producers expects rash of acquisitions and consolidation under pressures of slowing sales growth, declining profitability, higher capital and R&D funding

Patricia L. Layman, C&EN London

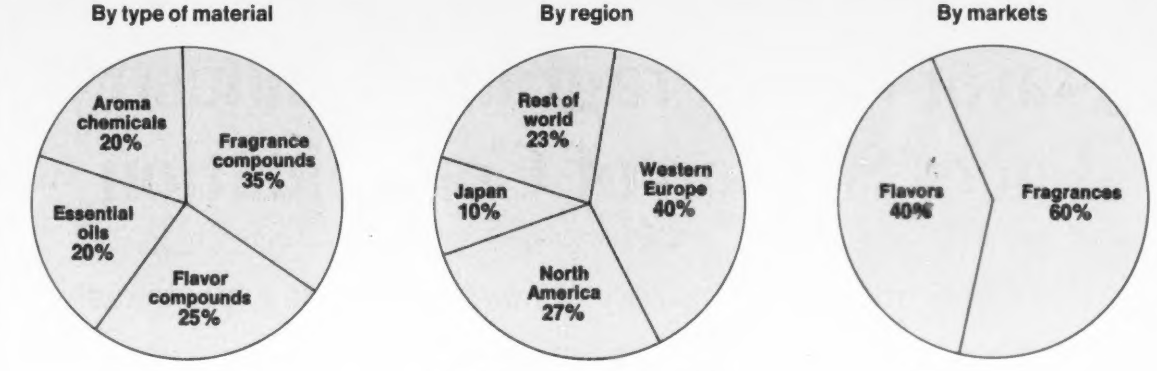
Earlier this month, the fifth largest flavors and fragrances supplier, U.K.-based PPF International, acquired the tenth largest, Norda, of the U.S. The combined company, a subsidiary of British-Dutch giant Unilever, will rank third in the worldwide industry. The acquisition confirmed one of the most persistent rumors circulating in the industry. It is also the latest in a series of mergers and acquisitions in that industry since the early 1960s—and the chances are good it won't be the last.

For an industry that historically has been burdened with praise, such as the cliché about "the sweet smell of success" often headlining stories, the world has changed. It's not that the business has collapsed, or that the major producers are going bankrupt—far from it.

But from the heady days of sales increases of 12 to 17% per year during the 1970s, growth has slowed significantly. Sales price erosion is cutting into suppliers' profitability. With increasing levels of customer service demands and demands posed by proliferating legislation, companies are having to increase their capital

Toiletries and household products provide huge market for fragrance chemicals

Balance characterizes flavors and fragrances industry's sales



Total 1984 market = $4.6 billion

spending and their R&D funding. And a continuing strong U.S. dollar is playing havoc with companies that must cope with currency exchanges.

Pressures like those weigh heavily on an industry that is particularly fragmented. The top 15 companies, worldwide, probably have just slightly less than 50% of the market; the remainder is shared by nearly 1000 other suppliers, many of whom sell to just one or two major accounts. As one market analyst notes, usually in an industry the top four or five companies account for about 40%; in the flavors and fragrances business, however, the top five companies have about 31%. Only about eight or nine companies have sales of more than $100 million per year.

That kind of competitive, fragmented environment has convinced some industry observers that no more than half a dozen major suppliers will still be in the business by the end of this decade. The medium-sized companies will disappear, they predict, merging together much as did four small companies in 1979 to form Universal Flavors & Fragrances, or as five small suppliers in Grasse consolidated into Sanofi, a subsidiary of French state-owned oil company Elf Aquitaine. Or they will be acquired by larger companies, as Norda has just been by PPF International. Or they will be bought by chemical or other companies, as BASF bought Fritzsche Dodge & Olcott in 1980, Hercules did with Polak's Frutal Works in 1973, or Union Camp did with Bush Boake Allen in 1982.

Typical of acquisitions outside one's area of expertise, sometimes they don't work out. For example, in 1968 Monsanto bought George Lueders, an essential oils supplier, expanded the business into Monsanto Flavor/Essence, and eventually sold it to Tenneco, which at the time owned Bush Boake Allen through its Albright & Wilson subsidiary. (Monsanto kept several commodity aroma chemicals, including ethyl vanillin.) Tenneco was just as uncomfortable in the flavors and fragrances business, and in 1982 sold the package to Union Camp—a sale that was almost universally welcomed at Bush Boake Allen.

What Union Camp believed it had going for it was an at least elementary knowledge of the industry through its terpene chemicals, many of which are used in the flavors and fragrances industry. That was a similar argument, for example, used by Hercules when it acquired Polak's Frutal Works in 1973. Hercules also was strong in such food additives as emulsifiers and thickeners and felt that the addition of Polak's Frutal Works' food flavors would help it round out its product line. And companies such as BASF and Bayer view flavors and fragrances as the higher-value extension of commodity chemicals they have long sold.

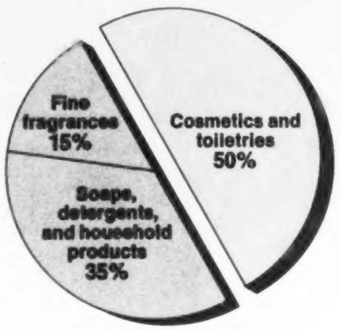
That's particularly true as synthetic chemicals have become an increasingly important part of the industry. Synthetics—from both petrochemical and natural (such as turpentine) raw materials—have become indispensable materials for the flavors and fragrances industry. They now account for more than 85% of the materials used in the fragrance side of the business. And even despite pressures brought by tightened regulations and consumerism, synthetics probably account for about 40% of the total flavors business, worldwide.

In terms of value, of course, synthetic chemicals have a smaller share of the market. But that is a reflection of the major selling point their suppliers make: Synthetics are cheap. There are some selling for what seems like a hefty tag, perhaps $25 to $50 per kg. But even double that would be far short of the inflated prices some of the rarer essential oils can bring—several thousand dollars per kilogram, for example, for Bulgarian rose oils. And the average price for the synthetics is actually closer to about $11 per kg.

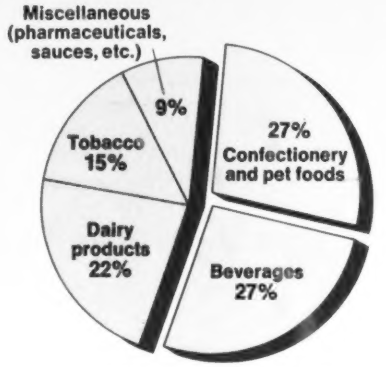
Aroma-chemical suppliers also point out that chemical synthesis is much more dependable than Mother Nature can be—synthetics aren't subject to the vagaries of weather, erratic crops, and lack of labor to harvest crops. And they undoubtedly get better throughput than some of the naturals—3000 kg of rose petals to give 1 kg of rose oil, for example.

Quantities also can be adjusted to reflect demand. Suppliers of synthetic aroma chemicals are fond of citing vanilla, as a case in point. There isn't enough vanilla—the natural material from vanilla beans—worldwide to satisfy the demand for vanilla-flavored ice cream in the U.S. alone. Hence, the continued demand for vanillin, the synthetically produced major constituent of vanilla.

Vanillin, used as a flavor enhancer and smoother in the manufacture of chocolate, is one of the few aroma chemicals that is used as is. Menthol is another; besides being compounded into mint flavors, it is used as a flavorant for menthol cigarettes. Most aroma chemicals, however, are destined for compounding. Their availability is what has brought about the change from the flavors and fragrances industry of the past to that of the sophisticated present, albeit in two distinct directions—one of fragrances, the other of flavors.


Cosmetics, toiletries lead fragrance sales

1984 sales = $2.8 billion


Confections, pet foods, and beverages top flavor sales

1984 sales = $1.8 billion

Fragrances—perfumes—have been around as long as there have been people to enjoy them: first in religious ceremonies and in funeral rites, and later in other ways in day-to-day life. But, by and large, they tended to be the province of the wealthy.

Indeed, in the heart of the French perfume industry, Grasse, the essential oils processed there went into the finest and costliest of fragrances. However, by the end of the 19th century, organic chemistry was opening the door to wider markets.

The discovery of coal-tar-based solvents and the development of fractional distillation technology enabled researchers to isolate the various constituents of flower, drug, and animal essences which had been used as "givens." Constituents could be isolated, identified, and eventually reproduced synthetically, if for no other reason than to extend the availability of the costly originals to meet burgeoning demand. No longer needed were such time-consuming and enormously expensive techniques as enfleurage, whereby petals of the desired flower are laid on thin layers of purified fats, which eventually draw out and hold the small quantities of fragrance chemicals within the flower itself. Such techniques could still be used, and still are, for essences for premium-priced perfumes, but it was no longer a must.

That marked a dramatic change in an industry which earlier had been tied into the medicinal and pharmaceuticals fields. Aroma chemicals were first isolated and identified in the early 1830s, when European chemists identified cinnamic aldehyde from cinnamon oil, and benzaldehyde from bitter almond oil. After 1850, more and more similar synthetics became available: esters of low-molecular-weight acids and alcohols, methyl salicylate (artificial wintergreen oil), benzaldehyde, vanillin, and so on.

During the early part of the 20th century, however, the development of synthetics began in earnest, mirroring the rapid developments in the field of organic chemistry. For the aroma chemical researcher, it has become relatively easy to take a mixture, or compound, and eventually take it apart. From the total impression that the compound's odor or flavor gives, the researcher can proceed through distillation, for three rough separations. First taken off are the low-boiling-point materials, which give a compound its "top note." Next come off the medium-boiling-point materials, which are the "body" of the compound. That leaves the "bottom note" high-boiling-point constituents of the compound.

Volatility is, of course, the key to the success or failure of a flavor or fragrance material, and that is more or less dependent upon a chemical's molecular weight. For example, the simplest aroma chemicals are roughly C_6 to C_8, with the range of optimum performance C_8 to C_{16}. If the material is above C_{20}, the chances are it probably will not be volatile, hence not of use to the researcher.

And there is frequently a correlation between structure and fragrance or flavor—a fruity scent associated with an ester, for example. It is impossible to predict exactly what the scent will be, merely by looking at the structure. But the researcher will have a rough idea, which trial and error will help to establish more exactly.

Once the compound has gone through distillation, it then will proceed through chromatography. Column chromatography could be used, for example, to isolate apolar hydrocarbons and oxides from the semipolar aldehydes and esters, in turn, from the polar alcohols and acids. More frequently these days, however, researchers will go straight to gas chromatography to isolate single compounds, and to mass spectroscopy to identify the chemicals in question. Despite the mystique kept up about Coca-Cola's unique formulation, for example, it probably would be possible for a canny chemist to reproduce it. However, without the marketing backup, he or she would be left with just a jumble of materials. It takes marketing, with good-quality products, to carry a jumble of chemicals, as the French perfume industry found out after World War I.

The age of synthetics really arrived in the 1920s, with the introduction of Chanel No. 5 perfume, a concocted fragrance that perfumers describe as "aldehydic" in its nature. Its success signaled perfumers that they no longer had to imitate slavishly the scents found in the garden, using materials found in the garden. It became a matter of imagination and creativity to build complex, sophisticated new fragrances.

And with the rise of synthetically produced raw materials and building blocks, costs tumbled dramatically. Fragrances began moving from the world of crystal flacons into fine soaps and cosmetics, and eventually into the more humble world of everyday soaps, detergents, and other household products. In fact, in the fragrances world, synthetics now probably account for nearly 90% of the volume of fragrance materials being marketed.

In the world of flavors, on the other hand, the numbers are quite a bit different, and, indeed, some estimates hold that synthetically produced products have less than half the worldwide market. In developing-country markets, synthetics have about 75% of the business, natural products the remainder. However, in Western Europe and the U.S., those percentages are reversed. One estimate for Western Europe, for example, holds that of all flavor ingredients, 75% are naturally obtained, 24% are synthetically derived "nature-identical," and the remaining 1% truly artificial, not to be found in nature. In the U.S., the proportion of naturally obtained material is the same, but the other two are lumped together.

Many companies compete in global flavors and fragrances industry

	Owner	When acquired or formed
International Flavors & Fragrances (U.S.)	Independent	1958
Givaudan (Switzerland)	Hoffmann-La Roche	1963
Naarden (Netherlands)	Independent	1905
Haarmann & Reimer (West Germany)	Bayer	1954
PPF International (U.K.)	Unilever consolidation	1946/1960
Firmenich (Switzerland)	Independent	1895
Florasynth-Lautier (U.S./France)	Merger	1981
Bush Boake Allen (U.K.)	Union Camp	1982
Takasago (Japan)	Independent	1920
Norda (U.S.)	Independent[a]	1924
Dragoco (West Germany)	Independent	1919
Fritzsche Dodge & Olcott (U.S.)	BASF	1980
Universal Flavors & Fragrances (U.S.)	Merger	1979
Roure Bertrand Dupont (France)	Hoffmann-La Roche	1963
Polak's Frutal Works (U.S.)	Hercules	1973
Felton International (U.S.)	Independent	1922

[a] PPF International announced acquisition July 20, 1984. **Note:** Companies listed in descending order of sales of flavors and fragrances.

That highlights one of the major influences upon this segment of the industry: governmental regulations and the impact of consumerism, and the differences region to region. Flavor suppliers feel that the regulations governing how such chemicals are labeled, in particular, are more flexible in Western Europe than in the U.S., with its black-and-white differentiation between natural and synthetic.

European laws tend to recognize as "nature-identical" those synthetically produced molecules which are the same as those naturally obtained. For example, vanillin produced from lignin, the major synthetic source, is the same molecule as the vanillin isolated from vanilla extract, and should be so considered. In the U.S., however, it would be considered strictly synthetic, tarred with the label "artificial vanilla" on food-package labeling. Flavor-chemical suppliers say that synthetics had been making significant inroads into the U.S. market until about 10 years ago. Since then, however, and particularly over the past five years, the trend has reversed to naturally obtained flavor chemicals, as food manufacturers scurry to emblazon "natural" on their labels.

A trend toward "natural" also is beginning to develop in Western European markets, suppliers believe, and it may well start happening in the important Far East market.

There are several ways to look at synthetically derived aroma chemicals. One way is to categorize them by feedstocks. Terpenes, for example: extracted from essential oils, or derived from α- and β-pinene, for such aroma chemicals as terpinol, terpinyl acetate, dihydromyrecenol, geraniol, linalol, citral, ionones, and citronellol, important in itself and as a source of further derivatives. The terpenes also can be obtained by total synthesis, coming from production of raw materials otherwise bound for synthesis of vitamins A and E, for example.

Petrochemicals provide a somewhat broader line of aroma chemicals from simple benzene derivatives. Phenol, for example, yields amyl and benzyl salicylates, and, to a smaller extent, through guaiacol, vanillin. Benzaldehyde and toluene give amyl cinnamic aldehyde and benzyl acetate. Xylene is the primary source for musk xylene and musk ketone. That is a short list, only of the petrochemical contribution to the 3000 or so aroma chemicals used in compounding flavors and fragrances.

On the other hand, synthetically derived aroma chemicals can be clumped together broadly by structure. That's how Hans Daeniker, a consultant with SRI International in Zurich, for example, looks at aroma chemicals. As he sees them, there are four basic categories: benzenoids and naphthalenoids, which make up more than 50% of the volume and 40% of the value of aroma chemicals; monoterpenes, 20% of the volume and 30% of the value; musk chemicals, 2% of the volume and 7% of the value; and a miscellaneous category of other aroma chemicals, making up about 25% of both the volume and value of the market.

For Daeniker, one of the most striking—and worrying—aspects of the present state of synthetic aroma chemicals is the general age of the chemicals. As he pointed out in a discussion on the subject at a conference on specialty chemicals in Monte Carlo last month, "Most of the big-volume aroma chemicals have been in use for 20 years or more. Very few new ones have been added lately." This is of concern, he says, because there is little patent protection left—an invitation for more manufacturers, lowered prices and thereby lowered price margins—and there is little left that a supplier can do better in terms of process improvement for any given chemical than its competitors have done.

This is despite the relatively high amounts of R&D money that major suppliers in the business spend. Givaudan, for example, budgets 7 to 8% of annual sales on R&D, roughly split evenly between applied and basic molecular research. Firmenich, which is privately held, has said in the past that it spends 12% of its sales on basic and applied research. Other major suppliers say that those percentages are typical for their industry. The smaller the company, of course, the less it spends on research and development. Nonetheless, the flavors and fragrances industry as a whole spends a sizable proportion on R&D—perhaps not so much as the pharmaceutical industry, but certainly more than the basic chemical industry.

So why so little to show for the effort? Daeniker figures there are four major reasons. First, he says, companies have concentrated on process technology, rather than new chemicals per se, improving process-engineering economics—various processes for making monoterpenes from pinenes, for example, or the synthesis of L-menthol. Second is a certain saturation of the market. "A good new product could find a market, but it is not badly needed," he says. There is already a large pool of chemicals from which to draw, with ready availability and reasonable prices. Thus the compounder already has almost unlimited possibilities for new combinations for new and original flavor and fragrance compositions.

Another reason is that many of the materials that have been introduced over the past two decades have been specialty materials that will replicate the trace components of naturally occurring flavors and fragrances. They have been analyzed, synthesized, and made available to the compounder for use, in trace amounts, to give a special effect to a composition. The trace amounts used help overcome the handicap of low volumes and often high prices. Large chemical manufacturers are not interested in this field, Daeniker says, and they leave it to the flavor and fragrance producers, or to small specialized chemical companies.

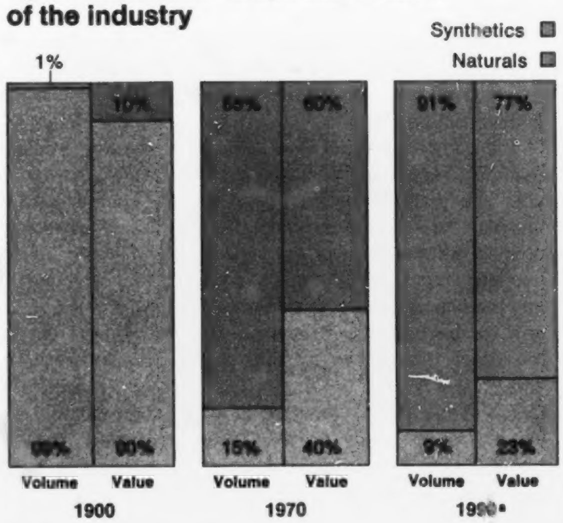
However, perhaps the overriding reason has been the increasing legal and toxicological requirements being imposed by various governments, particularly for new flavors and fragrances that will not be covered by any grandfather clause provisions. Moreover, in the flavor field, the demand by the public and politicians for natural products has retarded chemical research.

The industry, conscious of the increasing burden it would bear, and of its responsibilities as supplier, established in 1966 the International Organization of the Flavor Industry, and in 1973 a sister organization, the International Fragrance Association, to establish guidelines concerning safety aspects of the use of its raw materials and products. Both these associations, served by effective technical advisory bodies, are based in Geneva, and work closely with the U.S.-based Research Institute for Fragrance Materials (RIFM). RIFM depends for its judgments on an independent panel of international experts who study such topics as toxicology, pharmacology, and dermatology. The two Geneva-based associations, on the other hand, tend to concentrate on the legal side of things. Through their member national associations, they maintain contacts with governments, the medical profession, and so on, helping to guide their members and to contribute to the preparation of legislation.

For an industry in which commodity status easily can be reached at 1000 tons per year worldwide, and in which many more materials are sold in less-than-ton quantities, the costs for legal and toxicological tests are becoming prohibitive for much new-product development. In some respects, the testing is similar to that for pharmaceuticals, particularly for aroma chemicals destined for flavors. Even if it isn't quite so intensive or rigorous in the long run as that for pharmaceutical testing, the costs for aroma-chemical testing can mount up. And the thought of spending tens or hundreds of thousands of dollars on testing a material that may sell only several tons a year, worldwide, gives a board of directors pause. It is very hard, in fact, to predict if a material will even make it into the tonnage category, or will just stay at 100 kg per year—a not unusual market size for many fragrance and flavor materials.

In fact, if anything, the trend is toward a simplification of perfume formulas. Of the 3000 or so aroma chemicals used in compounding flavors and fragrances, about 20 are used in quantities greater than 1000 metric tons per year. Another 40 are used in quantities between 100 and 1000 metric tons per year, 60 between 10 and 100 metric tons, and about 250 between 1 and 10 metric tons. All the

Synthetics have swept into control of the industry



ª Estimates. **Source:** Givaudan

Compounding is the name of the game

In the flavors and fragrances industry, compounding is the name of the game, the most important area for companies in the business.

The compounder will start with raw materials—essential oils, and aroma chemicals both synthetically produced and also derived from essential oils. A product, a scent or flavor, is then compounded that, when eventually mixed into the finished product, will either be new, or be better or less expensive (preferably both) than existing products.

In a sense, the compounder is middleman for a variety of populations. Unless the compounder is backward integrated, for example, into essential oils, it buys from a host of smaller agricultural producers or state-run cooperatives. And, again depending upon the degree of backward integration into basic chemicals, the compounder will make its own aroma chemicals or buy them, often from competing suppliers. It then bridges the gap between basic raw materials and finished consumer products with its own compounds, which can be as little as 0.1% of a product yet be a crucial ingredient.

Some customers are giants who will buy only that compounder's aroma chemicals to do their own compounding—manufacturers such as Procter & Gamble, Colgate-Palmolive, and Henkel, for example, or food processors such as General Foods and Coca-Cola, with its original formula.

Other customers, however, will bring the supplier a brief to compete on, about the product desired. Sometimes it's a revamp of an existing product—the desire to be able to label "new, improved flavor," or "new, lemon-scented." More challenging to the supplier, however, is the new-product brief. For the flavorist, it is perhaps the opportunity to develop a new flavor that will withstand the rigorous production conditions by which a new extruded soy-protein snack will be made. For the perfumer, it might be the assignment of designing a fragrance and then making sure that it, or slight variations on it, will be suitable to also incorporate into matching soaps, shampoos and conditioners, skin creams, and lotions.

Moreover, it all has to be done with great discretion. The marketing mystique would be shattered by the public's awareness that this or that haute-couture designer is really just peddling a fragrance that a supplier developed. Although such enforced anonymity might be frustrating to perfumers and flavorists, they are comforted by knowing that in this small, intensely gossipy industry, the people who really count—their peers—know who has done what. And although fine perfumes are only about 15% of the fragrances business, for example, and a fairly small segment of most suppliers' sales, they are worth the effort because of image. A supplier that has had one winner will have more offers from customers to compete on the next project because of the enhanced reputation.

rest are used in quantities less than 1 metric ton, with many less than 100 kg per year.

Customer services also are becoming increasingly expensive. At one time, flavor and fragrance suppliers provided little beyond the compositions and chemicals needed for their customers' products. But that situation is long gone. Only rarely, say suppliers, are they the last to know what is happening in terms of product development. Only rarely, for example, will a food manufacturer design and develop a product only to think at the last moment, "Ah, yes, this must have an apricot flavor."

Much more commonly, flavor and fragrance suppliers will carry out their own research on such applied chemistry as skin cream emulsions, the effect of aerosol propellants on fragrances, fragrance substantivity for household detergents, and so on.

They are studying the legal requirements for their materials around the world, and generally can advise their customers as to what will be acceptable and where. Haarmann & Reimer, for example, has a data bank of the flavor substances it uses, worldwide, including available names, pharmacopoeia listings, legal requirements, and so on. It took the company 30 manyears to set it up, its directors say, and two chemists and 10 assistants work on it to keep it continually up to date.

Companies also are becoming far more marketing oriented. As the current jargon puts it, they are becoming marketing-driven, rather than technology-driven. At one time, says one company marketer, suppliers simply created fragrances and flavors and sold them. Now, they do extensive consumer-market research—what are consumers buying, and what will they be buying a year or two from now? What forms will the products come in? Where will they be sold, both in what countries and through what kind of stores and shops? What differences are there, country to country, region to region? Such market research probably wouldn't stop a marketer bound and determined to introduce a particular product into any given market, even if it was unsuitable—but it would reinforce the analysis and decisions taken by prudent marketers.

It is becoming increasingly difficult for smaller companies to give that kind of service, or even for medium-sized suppliers, who are being pressured to give more service.

Because larger companies can afford the R&D to improve process efficiencies and trim their own costs, the smaller firms also are bearing the brunt of generally low price margins which have been dogging the industry lately. Moreover, because the flavor and fragrance industry is fragmented, it has not been able to pull much bargaining weight with the giant customers it supplies in the largest fields.

Soaps and detergents, for example, are dominated by just a handful of international majors, who are determined to keep down the prices of their raw materials, as do companies such as Avon, L'Oreal, and Revlon in the cosmetics and toiletries field. Selling prices haven't kept up with other increases, suppliers say, and are certainly not at the levels that would be needed to justify building replacement or new capacity.

The result may well be a growing polarization of the industry between very large (probably not independent) suppliers and very small ones who sell to just one or two clients in a business area they know well and which isn't changing rapidly.

Larger, outside companies that decide to buy into the business should be aware of such trends, suppliers warn. They also should be aware that growth, although real (probably real growth of 3 to 5% per year through the rest of the decade), is nowhere near the former glory days, with high apparent growth rates.

A decline in the apparent rates has been caused, ironically, by the success of synthetics, some marketers contend, and by the ways available to chart the success of the industry. There are little hard data on the industry. Most of its compounds, for example, are tucked neatly away in the "miscellaneous" categories of data such as the synthetic organic chemicals statistics in the U.S.

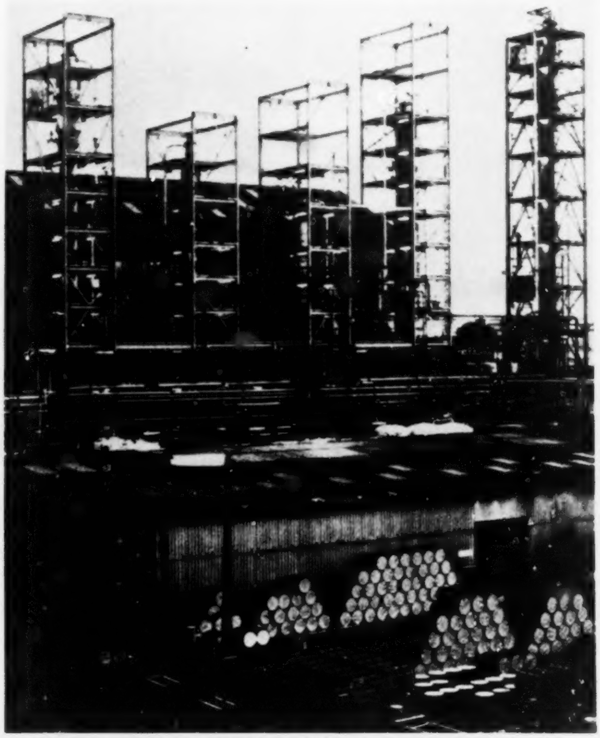
So what analysts tend to do is look at the sales of the companies in the business, both those that are published, and those that must be estimated from within corporate totals or from privately held secrecy. There is always some double-counting in the sales. For instance, if Fritzsche Dodge & Olcott processes its own essential oils and uses them in a fragrance compound that it sells, that is invoiced only once. But if it sells the essential oils to Givaudan, which in turn incorporates them into its fragrance compounds for sale, the essential oils would be invoiced twice. If the double-counting is done consistently, one can read a pattern over the years.

However, earlier there was not so much cross-selling in the industry. Smaller suppliers, in particular, would make their own products, mostly based on essential oils, for sale—one invoicing. Over the past 10 to 20 years, however, as synthetics became overwhelmingly dominant, smaller suppliers began turning to outside suppliers in much greater degree—an increase in double-invoicing. No more was being used, although more was being sold. According to some industry marketers, that gave the industry an artificially inflated apparent growth rate which has now slowed down, as the shift from own-manufacturing to buying in has been more or less completed.

Nonetheless, companies in the business are optimistic about it. They see their success coming from studying the market to find where the new-product opportunities are—for example, in new room and environmental fresheners, or in new food sensations, such as the recent U.K. hit, "hedgehog"-flavored potato chips; in doing what they are doing, better.

Companies also can benefit by spotting changes in existing markets and developing the products required. For example, the continued development of new detergent-based systems means that aroma chemical suppliers must continually be monitoring stability characteristics and revamping their formulations and compounds.

And flavor and fragrance suppliers also can be winners by keeping an eye on the Far East, which is the fastest-growing market for their materials, with an estimated growth rate of 8 to 15% per year through the rest of the decade. Helping to explain the high growth is that consumption is still low—value of about 50 cents per capita of flavors and fragrances, compared with nearly $5.00 per capita in both Western Europe and North America. And as the general economic conditions in a region improve, as they have in the Far East, manufacturers of consumer products can upgrade the ingredients they use for sale to consumers who are able and willing to pay for better-quality products.



Bush Boake Allen's Wildnes, U.K., aroma chemicals plant

"It doesn't need much in terms of an increase in disposable income to want the better things in life, after basic needs are satisfied," says SRI's Daeniker. "In the beginning, they will be satisfied with something cheap, then people will want something better. Flavors and fragrances make up only a few per cent of the total cost picture of consumer products, but the degree of success or failure for a product is much higher, because of the flavor or fragrance."

As Laszlo Unger, economist with Givaudan's strategic planning unit, puts it, "The better-positioned companies in the 1980s will be those that have integrated modern corporate management practices with traditional creativity in basic chemical research, flavor and fragrance ingredient compounding, and product development." That presupposes, he adds, "a flexible management, an independent and innovative group of creators, and a profound understanding of consumer and industrial marketing techniques as well as the needs of consumer-oriented companies." There—as easy as putting together the scent of a Mr. Lincoln hybrid tea rose. ☐

Mineral-Based Inorganics Struggle out of Recession

Production will increase notably this year for lime and sulfur but only marginally for potash and phosphorus

Bruce F. Greek, C&EN Houston

Along with some recovery in production, a little optimism has returned to producers of four of the largest-volume mineral-based inorganics—lime, sulfur, potash, and phosphorus. But production of all four is still well below their historic highs. Some may never again reach previous record highs because of special circumstances in their production worldwide or in their uses in the U.S.

Each of these four major-volume inorganics differs in its recovery pattern from the past recession. Lime, for example, may have a production gain of 11% this year over 1983, but potash production at best will be flat or up just slightly. But lime's 11% gain—the largest gain forecast for any of the four inorganics—is very close to the average annual increase expected this year for all major-volume chemicals.

The lack of big growth typifies the position of the mineral-based inorganics—that of mature products. They are continuing to be beset by competition in their markets from other chemicals, by imported derivatives and products made using these inorganics, and by the resulting pressures on prices and profitability. For most of these, capacity is declining as marginal units are shut down.

Key Chemicals

But what capacities are declining is difficult to say, because getting a good fix for this group is not easy. Lime kilns, for instance, vary widely in size, and production rates depend on the kinds of limestone used and product lines.

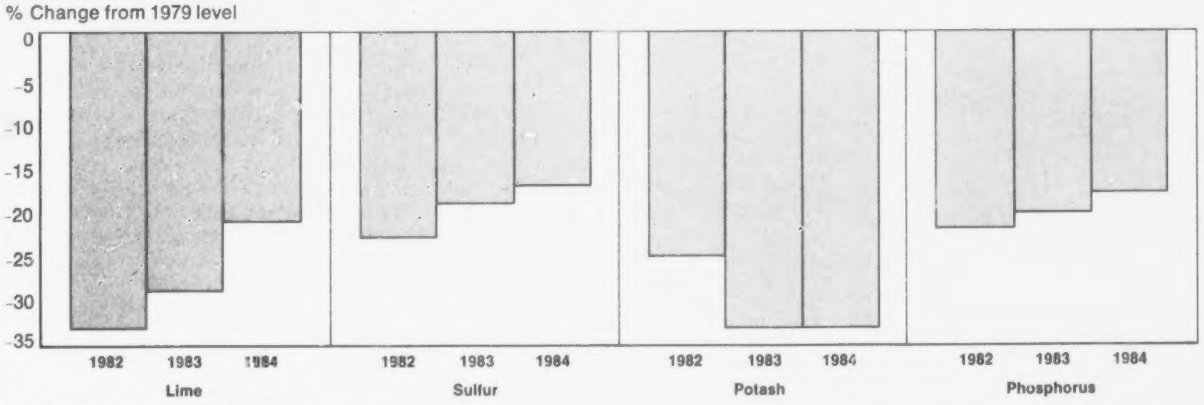
Estimating sulfur capacity has similar difficulties. For recovered sulfur, capacity has to be large enough to handle all sulfur that might come to the plants. But often the sulfur contents of crude oil and natural gas fed to refineries and to gas processing plants fall well below expected contents on which designs are based, making capacities much larger than needed.

For New Mexico potash producers, capacity is influenced by the average potassium oxide content of ores. The ore grade has been declining slowly in recent years about in line with forecasts of the life of the potash deposits. Capacity may be understated as a result of the decline in ore grade.

And similar to potash capacity, phosphorus furnace capacity assumes a phosphorus content in the rock fed to the furnaces. But, the decline in phosphate rock quality apparently has had little effect on capacity.

For details of the near-term outlook for these mineral-based inorganic chemicals, please see the following pages.

Output of mineral-based inorganics remains below prerecession levels



Sources: Bureau of Mines, C&EN estimates

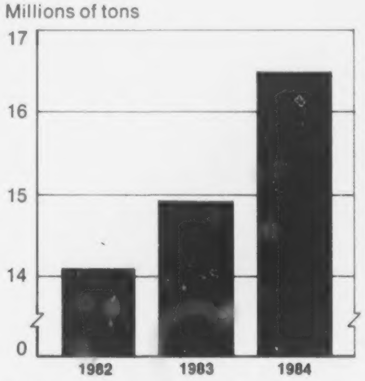
Key Chemicals

Lime

CaO-MgO

- ***Demand well up***
- ***Capacity excessive***
- ***Prices still weak***

PRODUCTION



Note: No capacity estimates are available.

HOW MADE

Calcining limestone (mainly $CaCO_3$) to make quicklime (CaO–MgO), then adding water to make hydrated lime, $Ca(OH)_2$

MAJOR END USES (U.S.)

Metallurgy (mainly steel flux) 45%, sewage and pollution control 15%, chemicals 10%, potable water treatment 10%, construction 5%

FOREIGN TRADE

Exports—less than 25,000 tons in 1984, imports—declining, 250,000 to 300,000 tons

PRICES

$45 to $55 per ton, depending on volume, location, and other conditions; discounts still significant

COMMERCIAL VALUE

$800 million for production, 1984

Lime production shows gains that fit the expected recovery from a difficult recession. Production in 1984 will be up 10 to 12% from 1983 to about 16.5 million tons.

That growth would seem to be substantial if compared to 1983's 6% gain over 1982. But these gains are relatively small compared to the very large declines in production following the historical production peak of almost 21 million tons in 1979. In effect, 1982's production of just over 14 million tons was down a third from the 1979 high.

No capacity estimates are available for lime. Production is divided between merchant and captive producers with about a quarter of production used captively. Both kinds of producers apparently are reducing capacity, however, as fewer producing plants are reported each year.

Energy is a big factor in the decision to scrap capacity. Lime requires relatively high amounts of energy for its manufacture, averaging more than 6 million Btu per ton of product. In spite of some improvements in designs to improve energy efficiencies and a major shift to use of coal as the fuel, some lime kilns with unfavorable combinations of energy cost, location, physical properties of the feed limestone, and end-use requirements are shut down from time to time. How many of these kilns are down at any one time depends on all these factors as well as current demand and price. Some kilns may remain inoperable for years before being restarted, but others become impractical to restart, especially with present lime selling prices.

Until the most recent recession, lime consumption grew slowly, as would be expected from a mature large-volume product. Most of the growth in volume came from the steel industry as it shifted over to basic oxygen and electric furnaces from open-hearth furnaces. The base for use of lime in metallurgy was large, making the fractional growth of this use lower than some of the newer uses such as stack gas scrubbing to remove sulfur gases. The big reduction in steel manufacturing caused by both the recession and a surge in imports of steel badly hurt demand for lime in metallurgy.

Now with the steel industry rebounding to meet demand by the auto and other industries, lime demand also is coming back. In 1984, lime going just to the steel industry could total 6.5 million tons if steel production reaches 100 million tons as forecast. This follows the rule of thumb that 6.5 lb of lime are needed as fluxing material per 100 lb of finished steel. This use alone would require 40% of lime production this year.

Use of lime in processing ores such as bauxite for aluminum production and ores of copper, tungsten, and uranium could add another 1 million tons to 1984 demand for lime. These nonferrous metal uses could then bring the total for all kinds of metallurgical uses to around 45% of total lime consumption this year.

Environmental uses of lime rank next in size. These uses cover a broad spectrum, ranging from scrubbing to various kinds of water treating. They likely will total 3.5 million to 4 million tons of lime in 1984, or nearly 25% of consumption.

Use of lime for scrubbing to remove sulfur gases passed the 1 million ton level in 1983 as forecast, but just barely. This use was up about 2% last year and probably will be up even more in 1984, as additional scrubbers are started up. The key to future use of lime in scrubbing, however, depends on legislation concerning acid rain. A host of yet-unresolved questions make forecasting lime demand in scrubbing difficult. For example, the new limestone injection multistage burner (LIMB) now appears experimentally to do a better job if hydrated lime is substituted for limestone. Also, the Environmental Protection Agency is pushing for a requirement that all new sources of sulfur gases must have some kind of scrubber to minimize pollution.

In the field of scrubbing, the dry technologies now go mainly to the use of lime as the reactant to take out the sulfur gases. Wet scrubbing usually uses limestone.

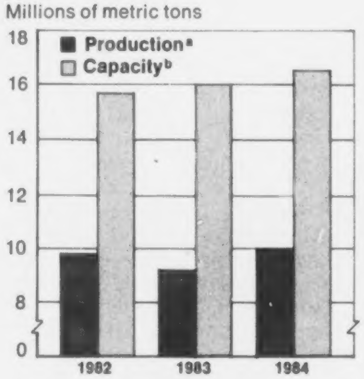
Most other uses of lime such as in construction, pulp and paper manufacture, potable water treating, and sugar beet processing, will show small gains, if any, in 1984.

Key Chemicals

Sulfur

- ***Demand improved***
- ***Capacity up some***
- ***Prices may rise***

PRODUCTION/CAPACITY



[a] From all sources. [b] As of first quarter; includes more than 5 million metric tons of standby capacity at smelters and recovery plants.

HOW MADE

Recovered from sulfur compounds processed in refineries, natural gas processing plants, and smelters; melted from underground deposits

MAJOR DERIVATIVES (U.S.)

Sulfuric acid 90%, chemicals 5%

MAJOR END USES (U.S.)

Fertilizer 60%, chemicals 20%

FOREIGN TRADE

Exports—holding at about 1 million metric tons in 1984, imports—rising, may exceed 2.25 million metric tons

PRICES

$130 per metric ton at Tampa, Fla.

COMMERCIAL VALUE

$1.25 billion for production, 1984

Sulfur producers have a good chance of getting back over the 10 million metric-ton-production level this year. And if they do, it will mean that production of sulfur in all forms will be up 7 to 8% from last year's levels. This improvement contrasts favorably with the 5% decline in production during 1983.

But even at the 10 million metric-ton level, production still would be more than 17% less than 1981's peak of 12.1 million metric tons. It probably will take several more years to set a new output record. The economic recovery plus the changes in farm policies will account for most of the gain in sulfur production by providing a good shot in the arm for demand this year.

Sulfur capacity will continue to rise as well during 1984. When averaged out over recent years, capacity to produce sulfur rises about as fast as does production and stays far ahead of output, giving chronically low capacity utilization rates. The reason for this is that new plant falls into the category of "must" capacity; that is, capacity installed to remove sulfur as a coproduct from natural gas and petroleum products and to avoid pollution by sulfur derivatives. Often this "must" capacity is "spared," or overbuilt, making it perhaps twice as large as actually needed. This is done to allow continued operation of the plants making wanted products even if the sulfur recovery units were to have mechanical problems.

Because of the "must-be-recovered" sulfur output, Frasch sulfur production acts as the swing production. Frasch sulfur, produced by pumping heated water into underground formations to melt the sulfur and lifting it to the surface by air pressure, has fallen nearly 50% since 1981, dropping to 3.20 million metric tons from 6.35 million metric tons.

Shipments of Frasch sulfur, however, did not fall quite so fast. They were 900,000 metric tons above production in 1983, after being below production in 1981 and 1982. Frasch sulfur producers obviously cleared out some of their inventories during 1983. At the end of 1983, inventories of Frasch sulfur were down to a bit more than 3 million metric tons, about 100,000 metric tons more than they were at the end of 1980, another year of low inventories.

For 1984, Frasch sulfur production has been forecast to rise to about 4 million metric tons. Some Frasch mines were shut down during the past year, reducing operating capacity. And one mine will been scrapped this year, again reducing actual capacity by a small amount. This loss of capacity probably will be more than offset by additional recovered sulfur capacity. Even so, enough Frasch capacity is running to hit easily the 4 million metric-ton mark.

Exports of sulfur in 1984 will hold at about 1 million metric tons, about what they were during the past two years. Slightly lower exports from Gulf Coast ports probably will be offset by higher exports of recovered sulfur from the West Coast.

Imports of sulfur, almost entirely from Canada and Mexico, will run as much as 2.25 million metric tons up from almost 1.7 million metric tons in 1983. Canada might be the source of 1.6 million to 1.8 million metric tons as production does well there. Mexico might ship as little as 400,000 metric tons, but probably more, as problems hold down production and aboveground stocks are low.

Consumption of sulfur in the U.S. has increased 10 to 12% over the estimated total for 1983 of almost 11 million metric tons. Consumption in 1984, however, is not expected to be back at the 1981 level of 12.8 million metric tons. The additional increase in consumption over production will come from imported sulfur from Canada, which also will make up for a small decline in imports from Mexico expected this year.

As might be expected with the forecast consumption increase, prices for sulfur also have been firming. An increase in the price at Tampa of $7.50 per metric ton apparently has held even though many phosphate fertilizer units are down for their annual maintenance turnarounds. Rumors also persist in the industry that another $5.00-per-metric-ton increase in price will be tried in September at the end of the third quarter.

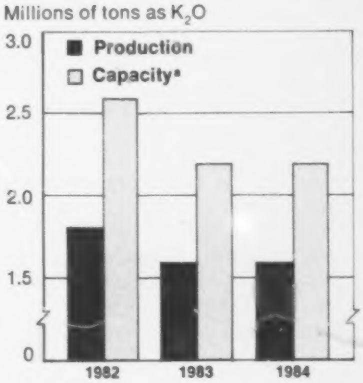
Key Chemicals

Potash

$KCl, K_2SO_4, K_2SO_4{\cdot}2MgSO_4$

- ***Demand holding***
- ***Capacity steady***
- ***Prices weakening***

PRODUCTION/CAPACITY



a As of first quarter.

HOW MADE

Shaft and solution mining of potassium salts, mainly the chloride, and subsequent purification

MAJOR END USE (U.S.)

Fertilizer 95%

FOREIGN TRADE

Exports—falling to about 300,000 tons in 1984, imports—rising to 5 million tons or more

PRICES

\$101 to \$109 per ton of K_2O equivalent; discounts heavy

COMMERCIAL VALUE

\$150 million for production, 1984

Potash holds an unusual—some might say enviable—position among most major-volume chemicals. It is one of the few whose demand exceeds U.S. production by several times, most recently fourfold.

Prospects are that for 1984, potash production will about equal that of 1983 at about 1.6 million tons as K_2O. (Most potash is sold as the chloride, with smaller quantities as sulfates. For uniformity in reporting, production, sales, consumption, and other statistics are given as the oxide.) This year's production will be down about 11% from 1982 production, following a pattern of falling production in recent years.

Potash consumption in the U.S. is expected to be up a sizable amount in 1984 for the usual reasons—better fertilizer demand as a result of the end of the payment-in-kind crop set-aside program; better feed grain prices, especially for corn; and some lower crop carryovers. Apparently, crop losses due to flooding in the Midwest this spring will not be large enough to trigger many low-cost disaster loans that would help future fertilizer demand.

For the first five months of the year, potash consumption ran about 8% higher than for the same period of 1983. If this consumption rate sets the pattern for all of calendar 1984, then consumption for the year will be between 6.1 million and 6.2 million tons.

The big gap between consumption and U.S. production is made up by imports, mostly from Canada. In 1983, imports accounted for close to 75% of consumption, a new high in recent times. Imports also offset U.S. exports of about 375,000 tons, which go mainly to Mexico.

Inventory building could account for part of the expected higher potash consumption in 1984. (Consumption is considered to occur when potash moves from the mine or import site.) Inventories are increasing this year in hopes that demand will surge strongly again this fall as it did in the latter part of last year.

But the inventory situation could be a reason for the recent list price cuts of about 10% for the July-August period. These price cuts are scheduled to end in September, according to several producers, as the fall fertilizer season begins and a better idea of fourth-quarter fertilizer production develops.

Inventories are up now and some mines and mills are taking the usual extended shutdowns for maintenance and vacation. This occurred last year during the slump in fertilizer demand when some of the shutdowns were long enough to bring formal announcements from companies to make clear that a permanent shutdown was not planned. The current shutdowns will go a long way, however, in helping to reduce stocks.

Even with the inventory reduction under way, prospects are not good for much increase in U.S. potash production. Adequate capacity remains to handle increased demand, but lower shipping costs on top of lower production costs make more imports likely during the rest of 1984 and on into 1985. New Canadian mines in the New Brunswick area probably can put potash into market areas all along the East Coast at lower net cost than can mines in New Mexico.

About 95% of potash consumption in the U.S. goes to fertilizers, with practically all the rest going to make various potassium chemicals. More than 80% of the potash used as fertilizer is the chloride with the sulfate and magnesium sulfate accounting for all but a small part of the remainder. Special crops get the sulfate forms and some few crops, most notably tobacco, get the small amount of potassium nitrate that is sold as fertilizer.

Concern arose last year over some New Mexico potash mines that might be classified as mines containing enough methane in their atmosphere to require special equipment and operating techniques. Cost of such equipment and operations probably would have led to closing of the mines. Such a classification didn't occur so the mines are in a category that requires very little additional capital.

These kinds of potential added costs combined with new low-cost production in other places, especially Canada, pose a continuing threat to U.S. potash production. Thus, prospects are good for more capacity reduction such as occurred in 1982 during the first major production decline.

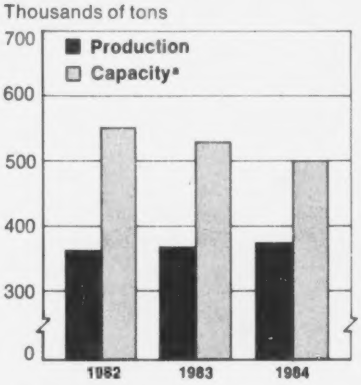
Key Chemicals

P_4

Phosphorus

- ***Demand up slightly***
- ***Capacity down***
- ***Prices steady***

PRODUCTION/CAPACITY



a As of first quarter.

HOW MADE

Reduction of phosphate rock in electric furnaces with carbon (coke) and silica as acids

MAJOR DERIVATIVES (U.S.)

Phosphoric acid and derivatives 85%, other chemicals 10%

MAJOR END USES (U.S.)

Detergents 45%, metal treatment 15%, foods and beverages 10%, chemicals 10%

FOREIGN TRADE

Exports—may reach about 20,000 tons in 1984, imports—negligible

PRICES

90 cents to $1.00 per lb

COMMERCIAL VALUE

$700 million for production, 1984

Phosphorus continues to face difficult times. Production in 1984 will be up just modestly, with capacity slipping down another notch.

The production numbers for recent years tell the tale of no growth for phosphorus. If all goes as expected in 1984, meaning no additional major reformulations of detergents, phosphorus production will rise 2 to 3% to about 375,000 tons. That would follow a rise of a bit more than 1% in 1983 from 1982 production, which fell more than 15% from 1981. In effect, then, the production recovery from the recession will be about a quarter of the decline.

Production capacity for elemental phosphorus has fallen in line with forecasts of little or no growth in output. Considerable capacity has been carried as installed capacity but not operating, and some of this capacity had been shut down as long ago as the late 1970s. Now industry sources do not expect any of the shutdown capacity located in Florida to run again. This is because of the higher electric power costs there than in the other elemental phosphorus producing locations in Tennessee and the Northwest. However, capacity in Tennessee also has been declining this year.

Because of the unlikelihood of the Florida plants' ever running again, revisions to C&EN's capacity estimates have been made to account conservatively for the shutdowns. About 25,000 tons of capacity were down before 1982, and about the same amount came down apparently permanently in that year, too. An additional 50,000 tons of capacity in Tennessee has been closed since the beginning of 1984.

For most of 1984, the total capacity available to produce phosphorus will be about 450,000 tons. This should bring the operating rate for the remaining capacity to about 83%, a much more desirable level for electric furnace plants, which represent high capital investment.

The revisions to phosphorus capacity to account for the long-shutdown plants clearly suggest that prospects for expansion are about nil. Both high investment and operating costs coupled with some decline in demand for phosphorus derivatives and pressure on prices of the derivatives also make building new furnaces very unlikely. Most large-volume derivatives of phosphoric acid that are made by burning elemental phosphorus and adding water, such as the sodium phosphates for detergents, can be made from wet-process phosphoric acid at costs that likely are lowered by the high depreciation charges of a new electric furnace. Even now considerable detergent phosphate materials are made from wet-process phosphoric acid.

Detergent phosphate materials, mainly sodium tripolyphosphate, account for a bit less than half of elemental phosphorus consumption in the U.S., down from more than 60% of consumption 15 years ago. Because of bans on phosphates in detergents in some communities, demand for phosphates that eventually wind up in detergents continues to decline. Bans have been effected, taken out, and then reinstated in some states. Other states may join in banning phosphate materials in detergents this year or later.

At the same time, reformulation of detergents could reduce demand for phosphate materials and, in turn, elemental phosphorus. Such factors leading to reduction in phosphates in detergents include growth in consumer use of liquid formulations, a trend toward lower washing water temperatures, and more use of zeolite builders in formulas

Offsetting slightly the negative factors in detergent and cleanser use of phosphate materials is the population growth. Consumption growth of detergents follows quite closely a fixed per-capita relationship. Thus, demand growth related to relatively small population increases will not offset, in terms of phosphorus use, bans on phosphates in detergents in states with large populations nor will it offset reformulations for whatever reasons.

The many other uses of elemental phosphorus are each a third or less the size of detergent and cleanser demand. Only one—metals treating—is showing much life this year, and this because of the recovery in durable goods, especially auto production. This includes both aluminum polishing and phosphate coatings as paint bases.

PRELIMINARY PROGRAM
1984 International Chemical Congress of
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CHEMICAL & ENGINEERING NEWS

Flame-Generated Fine Particles

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CHEMICAL & ENGINEERING
NEWS

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AUGUST 6, 1984

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- **EPA proposes to cut lead use in gasoline to 0.1 g per gal.** Page 4
- **Decline in world oil prices could be boon or bane for producers of chemicals.** Page 5
- **Center to study plant genetics will be USDA-UC Berkeley cooperative effort.** Page 5
- **Critic files motion to bar private industry from tests that would release genetically engineered organisms into environment.** Page 5
- **NRC committee recommends priorities for major materials research facilities.** Page 6
- **Senate-passed version of hazardous waste regulations is more lenient than House bill.** Page 6

Cover: Laser beam is used to measure size of flame-synthesized particles at the University of New Hampshire

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Beatrice Foods will sell its chemical and fertilizer units; Japan's booming economy puts chemical firms back in the black. **Page 8**

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Science Policy

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Technology

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World Bank May Eliminate Its Technology Advisory Function

Budget cuts and economy in developing countries force bank to reorder its priorities, and critics say technology it supports hasn't delivered

Wil Lepkowski, C&EN Washington

Policy advice on science and technology over the years has become a fully accepted way of helping institutions save money and provide for the common good. The White House has its Office of Science & Technology Policy, Congress its Office of Technology Assessment, and even governors and state legislatures their science advisory staffs. All know that technical knowledge drives economies and that sage advice on it can head off technological boondoggles.

So it seems a little peculiar that the biggest technical assistance organization in the world, the International Bank for Reconstruction & Development (commonly known as the World Bank) is thinking of eliminating its own small technology advisory function.

It hasn't yet and in the end may not, but the bank, under its president A. W. Clausen, who in 1981 succeeded Robert McNamara, is in the process of reordering its priorities and strategies. The bank faces pressures from worsening economic conditions in the developing countries and a tightening administrative budget at its headquarters in Washington, D.C.

The science and technology overview function is headed by Charles Weiss Jr., a former biochemist who came to the bank in 1971 as McNamara's science adviser. Under McNamara, Weiss was able to build up a team of eight full-time professionals. But when McNamara retired and Clausen settled in, Weiss' office was merged into the new, but isolated, Office of Environmental & Scientific Affairs, headed by James A. Lee.

Clausen: an interdependent world

Weiss is trying to save the technological overview function against bank budget cutters, convinced that good technological advice can enhance the effectiveness of the bank's programs around the world. At the same time he believes the work of technical advice at the bank is woefully unknown to the science policy community. "I feel strongly that science and technology assessment is an important function of the bank, and that it should be saved, whoever runs it," Weiss says.

The scientific community, Weiss believes, could learn a lot from the way the bank goes about financing science and technology. "In the hands of the bank," he says, "the development assistance loan has become a flexible instrument for the promotion of scientific and technological development. This may come as a surprise to scientists and technologists who are accustomed to grant financing. At the same time, the willingness of governments to borrow for projects that support science and technology shows the importance they attach to this aspect of development."

And since technology is now so pervasive an element in world development, says Weiss, "it may well be that we are witnessing the beginnings of a new type of technology policy based on financial institutions, unlike our current technology policies that for the most part are based on research institutions."

All that may well be, but to most of the economically oriented staff at the bank, technological advice performed from the apex of the administrative triangle needs a lot of selling. The bank already employs 600 to 700 technically trained men and women, all there to advise on every field from health care to satellite technology. Most of the bank's brigades of economists think they are enough. But that isn't what Weiss' work involves. His function provides overview, or assessment of relationships between technology and everything else that's relevant to its optimal use. So Weiss faces the problem of boosting the bank's work while reminding it of its deficiencies.

To outsiders, the bank hardly projects the image of a major technological agency. It is seen as first a development agency, then a bank. But in fact, most of the money it lends ($15 billion last fiscal year) goes into technological projects—industries, farms, mines—that enable the assisted country to become an exporter and thus enjoy a viable

Weiss: new type of technology policy

C&EN staff photo

economy. World Bank success stories include South Korea, Taiwan, Singapore, and, in certain respects, though crushed by huge debts, Brazil and Mexico. Each country has created an industrialized economy with products that are competitive in export markets.

But to the bank's critics, the technology it supports hasn't really delivered. Poverty is more grinding than ever. The "Third World" remains a pretty miserable place. It is torn by revolution and savaged by debt, owing western financial institutions at least $600 billion, with little prospect of ever repaying the principal or even the interest.

Most developing countries cannot hope to become a Taiwan or a Korea. The markets just aren't there. Attempts to develop them for rice and electronics in the Philippines, for example, failed totally.

Thus, for 40 years, western science and technology have promised joy and prosperity to the world's downtrodden, and the results have been somewhat less than desirable. Moreover, critics say, much of the industrial technology devised by the bank's economic planners was selected not to employ as many people as possible but to reduce the human workforce for the sake of export-enhancing efficiency and productivity along the model of countries already industrialized.

"This cycle has dreadful political effects," says Princeton University political science professor Richard Falk. "The export compulsion capitalizes agriculture at the expense of marginal peasants and domestic demand, while the investment compulsion both depresses real wages and represses the efforts of workers to resist."

Says Cheryl Payer in her book, "The World Bank—A Critical Analysis," published in 1982: "Only regular, decently paid employment can be the solution to poverty. While the bank has announced a few token projects for creating employment, it has more typically exerted its influence to keep wage levels low in order to encourage foreign investment and export enterprises."

Comments development expert Lester Brown, director of the Washington D.C.-based Worldwatch Institute, "We need to counteract the purely economic assessment of projects. For example, in the Philippines it makes no sense to be pushing nuclear power, which is so capital-intensive. It may make more sense to go the biomass route where land surplus is used to grow trees that can fuel small 3-MW power plants and in the process employ thousands of people. That kind of approach did not exist a few years ago. It takes capability in technology policy to see things the specialists often can't see."

The bank had nothing to do with nuclear power development in the Philippines and Weiss' shop has documented as well as assisted development of small-scale, labor-intensive technologies around the developing world. But enough experts have studied the bank that their criticisms are being heard.

Another point for bank criticism has been its waffling position on population control. In the bank's 1984 World Development Report, just issued, Clausen tries to make the link between new economic realities and world population growth. "The general public remains insufficiently aware of the growing links among nations over the past few decades," he says, "and of the extent today of international economic interdependence. In an increasingly interdependent world, low growth, fiscal and labor market problems, and resulting inflation in industrial countries have taken a heavy toll in developing countries.

"Exports have suffered," he says, "fear of protectionism has increased, and high real interest rates have made debt servicing a costly burden. If the industrial countries fail to regain the growth rates they managed in the 1950s and 1960s, many countries in the developing world will have great difficulty making progress in the years ahead."

With the outlook so grave, it would seem that Clausen might value an office that would give him some criteria for assessing those technologies that help, and those that detract from, balanced development of a region. It is now acknowledged, for example, that contraceptive devices and birth control pills, promoted through bank projects, have had little impact on controlling population in developing countries. But in his report, Clausen says little about new sets of policies and perceptions the bank will pursue to tackle the problem effectively.

"The World Bank's efforts in the population field," declares population consultant Peter Huessy, who has just completed a lengthy study of the problem for Population Reports International of Washington, D.C., "have been limited, uncreative, without substantial impact, and of

Agriculture gets biggest share of World Bank loans

$ Millions, fiscal 1983	Loan amount	% of total loans
Agriculture and rural development	$ 3,698	25.5%
Energy	2,838	19.5
Transportation	1,924	13.3
Development finance companies	1,238	8.6
Water supply and sewage	811	5.6
Industry	692	4.8
Urban development	554	3.8
Education	548	3.8
Small-scale enterprises	531	3.7
Population, health, and nutrition	118	0.8
Telecommunications	57	0.4
Technical assistance	53	0.4
Nonprojects (general assistance)	1,438	9.9
TOTAL	**$14,477**	**100%**

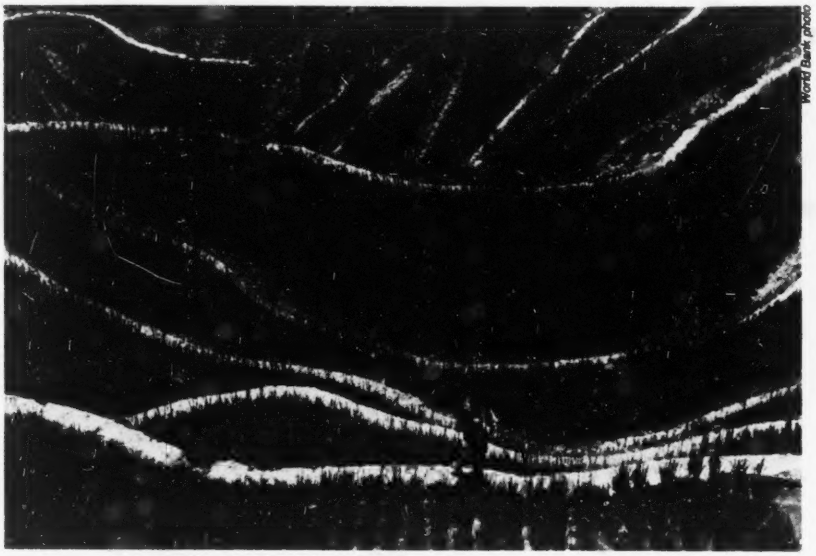
Source: World Bank

little institutional priority. The bank has not urged governments to institute policies to encourage couples to have smaller families, a prerequisite of substantial reductions in population growth." Huessy refers to such practices as guaranteeing housing and farm acreage to couples who limit to two the number of children they have.

The World Bank, being such a large target, is easy to knock. And no one can argue that its projects in irrigation, telecommunications, farm productivity, roads, railroads, ports, health care, and forestry preservation have failed. It's just that new approaches are needed to reach the poorest. Better choices of technology are at least part of the answer, and this is where Weiss' operation comes in.

"There are lots of dimensions to development," Weiss points out. "The thought processes of economists, plus sociologists, plus technologists, plus agriculturalists are all involved. And all should be in touch with each other and understand what each other has to contribute." His office, in fact, runs a training program set up along those lines "to help people think about development from a common frame of reference," he says. "This dimension of development does not receive enough attention. Each of us will see issues the other did not pick up."

Weiss knows both high and low technology and has become convinced over the years that high tech is very rarely the answer to solving problems at the village level. For example, a study on agricultural mechanization in India done in another part of the bank showed that tractors didn't raise the intensity of cultivation but actually led to the eviction of sharecroppers. The tractors, to justify their worth, forced expansion of farms and led to the uprooting of sharecropper households. So rather than providing jobs for the poorest—something the bank purports to want to do—it actually reduced employment. The final solution was animal-driven plows and simple toolbar carriers "as the improved implement offering the greatest potential benefit."


World Bank photo

Rice is planted on terraces in the Philippines

Weiss' case for keeping a technology advisory position at the bank is a compelling one, but perhaps waiting for its proper political time to come. Robert F. Wasserstrom, a senior associate at the World Resources Institute in Washington, D.C., has worked at the bank as an environmental consultant and currently is studying the institution's policies over the years. He says there's no doubt that balanced technological input is needed in the bank, but that there are sets of mind that work against it.

"I have to keep reminding myself," he says, "that the bank is still a bank. Its project officers have to see each project in terms of its ability to pay for itself, that is, to be successful enough so that the loan will be paid off. That's all bankers are interested in: whether the criteria for, say, a road are met and that the loan will be repaid, not necessarily that the technology is the most appropriate kind.

"You can use either set of criteria to evaluate a project. And it's true that if you ask whether any given project got down to helping the poor, in most cases you'd find bank projects wanting. One thing I find about the bank is that the whole process is so disarticulated. For example, performance evaluation and financial monitoring are not tied together. And of course, technological advice across the board is not brought in at all. That's why a function like technology policy doesn't really fit at the World Bank. That kind of advice tends to hold things up when someone like Chuck [Weiss] says there might be a better way to do something."

Strangely, the National Academy of Sciences has seen little reason to interject itself in the principle that the World Bank could use a strong technology assessment component. "I thought the elimination of Chuck's job already had happened," says Victor Rabinowitch, head of the academy's office of international affairs. "The science community isn't upset" over the possible elimination of the bank's technology assessment office, he says, "because the World Bank's science program was never very visible. Lots of us think that the World Bank's contribution to the development of science and technology in the developing countries is enormous. But its program hasn't involved the American scientific community in any significant way."

So it is questionable whether the cool logic inherent to science and technology can steer the bank toward policies that actually do ensure a more direct tie-in between know-how and poverty. In other words, whether the Chuck Weisses of the world can exert enough influence to help direct a revolution in finance and technology to help developing countries get out of the mess they're in. □

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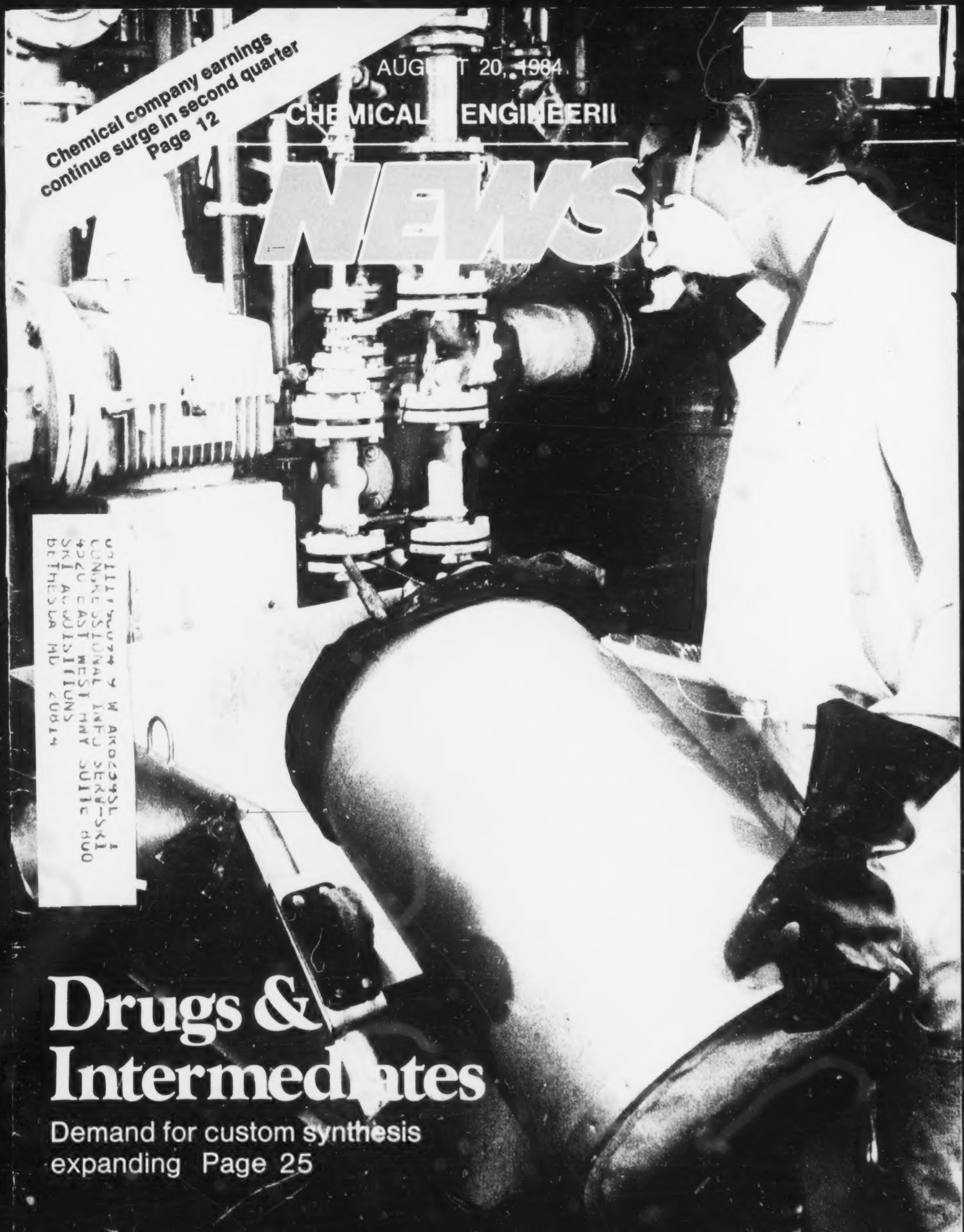
NEWS

Chemical company earnings continue surge in second quarter Page 12



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CHEMICAL & ENGINEERING NEWS

AUGUST 20, 1984

News of the Week

- **New study of babies whose fathers were Vietnam veterans shows no evidence of higher than normal rate of birth defects. Page 6**
- **Jet fuel additive claimed to prevent postcrash fires to undergo critical test. Page 7**
- **Scientists offer to go to the U.S.S.R. as guarantors if Soviets allow Elena Bonner to seek medical treatment abroad. Page 7**
- **SEC and Stauffer Chemical resolve suit over firm's accounting practices. Page 8**
- **Three companies lease plots in dioxin-contaminated Times Beach, Mo., for research purposes. Page 8**

Cover: Workman charges a reactor at Eastman Kodak's custom synthesis pilot plant in Rochester, N.Y.

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Business

The healthy gains in U.S. chemical industry earnings continued in the second quarter, through stepped-up demand for products, stable costs, and increased productivity. **Page 12**

International Business

Combined earnings of Canada's four largest chemical firms rose to $37.2 million in the second quarter, 65% ahead of first-quarter 1984, but not all firms performed equally. **Page 18**

Government

House-passed bill to extend Superfund would raise taxes, require EPA to follow a mandatory cleanup schedule. **Page 20**

California officials and scientists move to correct mistakes that turned Stringfellow waste dump problem into emergency. **Page 22**

Technology

CHEMRAWN III, on resource material conversion, emphasized the need to develop and implement new technologies for making chemicals when oil supplies eventually are depleted. **Page 63**

Product Report

Custom synthesis of drugs and intermediates is a thriving, if sometimes risky, business. Page 25

Chemical Firms Post Strong Gains in Second Quarter

William J. Storck, C&EN New York

As indicated by early company reports, earnings of U.S. chemical producers continued to grow strongly in the second quarter, climbing an average of 52% from those in second-quarter 1983. Coupled with the even stronger 70% annual growth in this year's first quarter, the industry's earnings for first-half 1984 gained 59% from last year's first half.

This happy state of affairs has been spurred by a combination of increased demand for products, relatively stable costs, and increased efficiencies. Although the earnings gains extended widely among U.S. chemical companies as well as diversified and oil companies that produce chemicals, the gains were larger for basic chemical companies than for the smaller, more specialty-oriented firms. And they were bigger for chemical and diversified firms than for oil companies.

Based on results posted by 30 of the largest U.S. chemical companies for the second quarter, the 52% increase brought combined earnings of these companies to $1.13 billion. Combined sales of these companies rose 11% from last year's second quarter to $18.6 billion. The much larger increase in earnings than in sales gave a healthy push to chemical profitability in the quarter: Average profit margin rose to 6.2% from 4.5% a year earlier.

Greater demand in many of chemicals' end-use markets played no small part in the industry's achieving these results. For instance, the automobile market has continued strongly, and housing and commer-

Chemical industry leaders for the second quarter . . .

Sales

Rank	$ Millions	Rank 1983
1 Dow Chemical	$2986.0	1
2 Union Carbide	2403.0	2
3 Monsanto	1801.0	3
4 W. R. Grace	1741.4	4
5 PPG Industries	1100.0	5
6 American Cyanamid	1000.0	6
7 Celanese	860.0	7
8 Hercules	662.0	8
9 Rohm & Haas	554.8	9
10 Olin	545.3	10

Earnings[a]

	$ Millions	Rank 1983
Dow Chemical	$184.6	2
Monsanto	145.0	1
Union Carbide	126.0	4
PPG Industries	86.1	3
American Cyanamid	57.4	6
W. R. Grace	57.4	7
Hercules	53.4	8
Rohm & Haas	51.9	5
Celanese	47.0	12
Air Products	38.2	10

Profitability

	Earnings as % of sales	Rank 1983
International Flavors	16.2%	1
Loctite	11.9	4
Freeport-McMoRan	11.9	2
Nalco Chemical	11.1	3
First Mississippi	9.8	9
Lubrizol	9.7	5
Rohm & Haas	9.4	6
Petrolite	8.5	7
Air Products	8.5	13
Hercules	8.1	11
Monsanto	8.1	12

. . . and for the first six months of 1984

Sales

Rank	$ Millions	Rank 1983
1 Dow Chemical	$5902.0	1
2 Union Carbide	4796.0	2
3 Monsanto	3533.0	3
4 W. R. Grace	3238.7	4
5 PPG Industries	2100.0	5
6 American Cyanamid	1938.6	6
7 Celanese	1697.0	7
8 Hercules	1281.0	8
9 National Distillers	1132.6	11
10 Rohm & Haas	1102.9	9

Earnings[a]

	$ Millions	Rank 1983
Monsanto	$320.0	1
Dow Chemical	306.6	2
Union Carbide	233.0	3
PPG Industries	160.2	4
American Cyanamid	113.9	7
Rohm & Haas	108.2	5
W. R. Grace	103.4	6
Hercules	101.1	8
Celanese	91.0	19
Air Products	74.8	9

Profitability

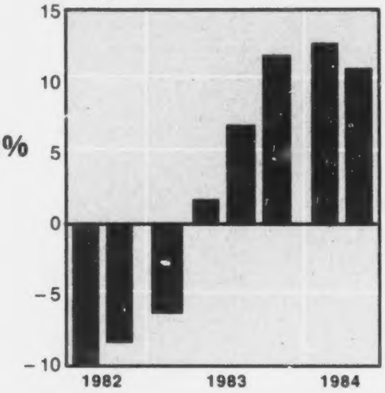
	Earnings as % of sales	Rank 1983
International Flavors	15.7%	1
Freeport-McMoRan	11.4	3
Loctite	11.3	4
Nalco Chemical	10.8	2
Rohm & Haas	9.8	6
Monsanto	9.1	9
Lubrizol	8.9	7
Petrolite	8.4	5
First Mississippi	8.4	12
Air Products	8.3	10

[a] After taxes. **Note:** Based on 30 companies listed on page 14.

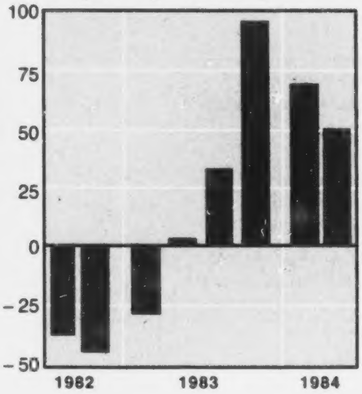
Chemical industry 1984 second-quarter results

- Sales up 11%
- Earnings climb 52%
- Profit margins rise to 6.2%
- Production up 8%
- Prices increase 4%

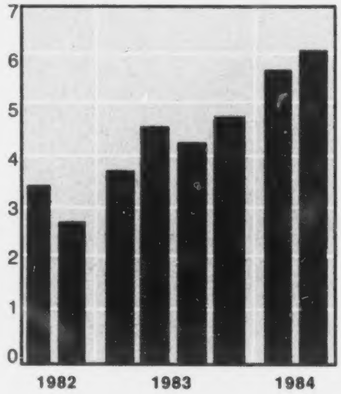
Sales
% change from year-earlier quarter



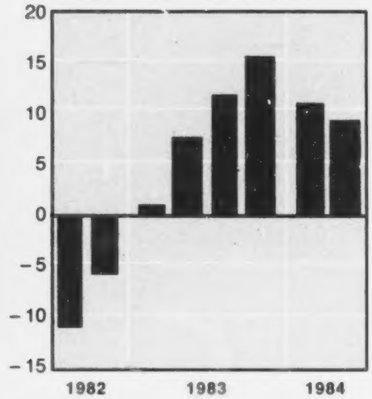
Earnings
% change from year-earlier quarter



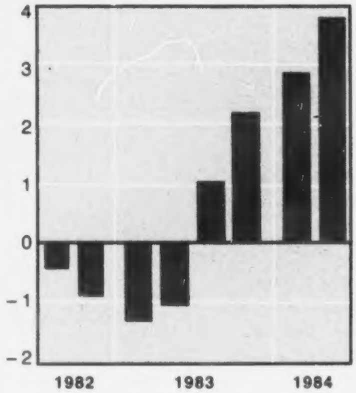
Profit margins
After-tax earnings as % of sales



Production
% change from year-earlier quarter

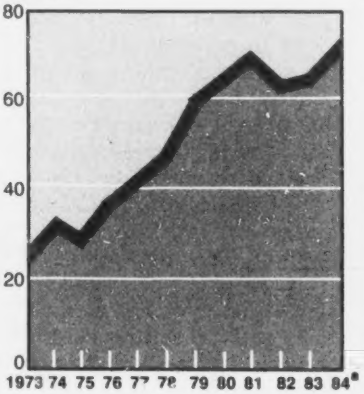


Prices
% change from year-earlier quarter

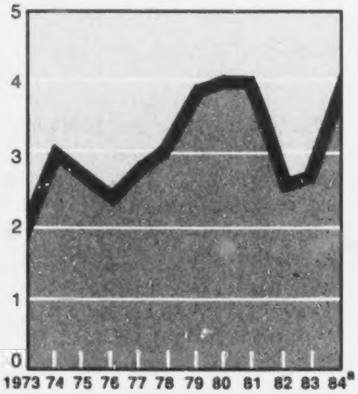


Sales in 1984 will increase 12% and earnings will be up 45% from last year, boosting profitability markedly

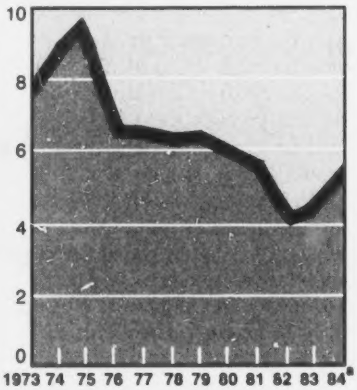
Annual sales
$ Billions



Annual earnings
$ Billions



Annual profit margins
After-tax earnings as % of sales



a C&EN estimates. **Note:** All sales, earnings, and profit-margin data are based on combined results of the 30 companies listed on page 14.

Earnings of major chemical companies rose 52% on 11% sales increase

	SECOND-QUARTER 1984						FIRST-HALF 1984			
	Sales	Earnings[a]	Change from 1983		Profit margin[b]		Sales	Earnings[a]	Change from 1983	
	$ millions)		Sales	Earnings	1984	1983	($ millions)		Sales	Earnings
Air Products	$ 448.9	$ 38.2	10%	46%	8.5%	6.4%	$ 901.0	$ 74.8	8%	42%
American Cyanamid	1,000.0	57.4	11	34	5.7	4.8	1,938.6	113.9	13	62
Celanese	860.0	47.0	3	124	5.5	2.5	1,697.0	91.0	6	237
Chemed	85.9	6.1	32	24	7.1	7.5	167.3	11.1	33	29
Crompton & Knowles	62.6	2.4	3	14	3.8	3.5	122.4	4.2	6	24
Dow Chemical	2,986.0	184.6	9	98	6.2	3.4	5,902.0	306.6	12	89
Essex Chemical	57.0	3.3	25	371	5.8	1.5	101.0	5.2	16	126
Ethyl	446.5	31.8	0	21	7.1	5.9	864.5	56.5	2	22
First Mississippi	85.8	8.4	34	87	9.8	7.0	157.9	13.2	42	113
Freeport-McMoRan	217.8	25.9	17	24	11.9	11.2	420.5	47.9	8	14
H. B. Fuller	117.3	4.0	9	9	3.4	3.4	222.1	6.1	11	11
W. R. Grace	1,741.4	57.4	8	42	3.3	2.5	3,238.7	103.4	9	40
Hercules	662.0	53.4	16	44	8.1	6.5	1,281.0	101.1	15	57
International Flavors	130.9	21.2	4	1	16.2	16.6	254.5	40.0	3	2
International Minerals	469.8	25.2	8	80	5.4	3.2	858.6	52.0	7	48
Loctite	63.6	7.6	11	46	11.9	9.1	126.2	14.2	12	42
Lubrizol	222.7	21.6	5	18	9.7	8.7	431.4	38.5	9	31
Monsanto	1,801.0	145.0	12	38	8.1	6.5	3,533.0	320.0	14	57
Morton Thiokol	522.5	26.2	17	33	5.0	4.4	1,063.8	54.9	19	27
Nalco Chemical	183.4	20.4	12	11	11.1	11.2	358.9	38.7	11	11
National Distillers	539.4	12.2	12	10	2.3	2.3	1,132.6	47.6	23	74
Olin	545.3	33.0	11	38	6.1	4.9	1,071.8	60.2	11	29
PPG Industries	1,100.0	86.1	18	37	7.8	6.8	2,100.0	160.2	17	69
Pennwalt	272.5	11.6	11	68	4.3	2.8	530.0	21.0	9	59
Petrolite	70.4	6.0	−3	9	8.5	7.6	143.2	12.0	−1	1
Reichhold Chemicals	219.1	7.9	12	20	3.6	3.4	428.4	13.4	15	25
Rohm & Haas	554.8	51.9	6	20	9.4	8.3	1,102.9	108.2	12	41
Stauffer Chemical	380.9	14.1	31	def	3.7	def	799.7	30.1	22	110
Union Carbide	2,403.0	126.0	10	103	5.2	2.8	4,796.0	233.0	10	112
Witco Chemical	382.5	16.2	11	31	4.2	3.6	749.2	30.9	12	34
Total 15 largest companies	**$16,080.6**	**$ 975.4**	**10%**	**55%**	**6.1%**	**4.3%**	**$31,481.5**	**$1883.4**	**12%**	**66%**
Second 15 companies	**$ 2,552.4**	**$ 176.7**	**14%**	**38%**	**6.9%**	**5.7%**	**$ 5,012.7**	**$ 326.5**	**13%**	**28%**
GRAND TOTAL	**$18,633.0**	**$1152.1**	**11%**	**52%**	**6.2%**	**4.5%**	**$36,494.2**	**$2209.9**	**12%**	**59%**

a Earnings from operations excluding major nonrecurring and extraordinary items. b Earnings as a percentage of sales. def = deficit.

cial construction have pushed ahead, although there are signs of slowing as higher interest rates put a squeeze on home buying. Agricultural markets also have been up from a year ago, as the government ended its payment-in-kind crop setaside program, and farm income was high enough to support buying this year.

There is still room for expansion, however, as U.S. exports of chemicals have shown no signs of increasing in the face of the strong dollar, compared to foreign currencies. And this same strong dollar is making foreign-made chemicals cheaper, increasing imports into this country and crowding some chemical markets.

Nonetheless, expanding demand for chemicals pushed production up about 8% in the second quarter over the same period a year ago. This represents some slowdown in the growth rate, though, as chemical production in the first quarter was up 11% from the same period the year before, according to government figures. And it is just about half the almost 16% rise in output registered in fourth-quarter 1983.

Chemical prices also started to pick up more in the second quarter after languishing from the effects of the recession. According to the government's producer price index, prices for chemicals and allied products in the second quarter averaged 3.8% higher than in second-quarter 1983. This represents an increase in the chemical inflation rate since the first quarter, when prices were up 2.9% from a year before.

An examination of the second-quarter results shows that the larger, more basic-chemical-oriented firms surpassed the smaller firms in earnings performance, but not in profitability. Sales for the 15 larger firms increased 10% to a total of $16.1 billion. For the 15 smaller firms, sales rose 14% to total $2.6 billion. However, combined earnings for the 15 larger firms increased 55% to $975 million, whereas earnings for the smaller firms rose 38% to $156 million. Thus, profit margins (earnings as a percentage of sales) for the larger firms averaged 6.1%, up from 4.3% a year ago. For the small-

FIRST-HALF 1984		12-MONTH RUNNING DATA			
Profit margin[b]		Change from 1983		Profit margin[b]	
1984	1983	Sales	Earnings	1984	1983
8.3%	6.3%	7%	42%	8.0%	6.0%
5.9	4.1	9	61	5.6	3.8
5.4	1.7	11	def	5.2	def
6.6	6.9	25	23	6.4	6.5
3.4	3.0	9	39	3.0	2.3
5.2	3.1	12	144	4.1	1.9
5.1	2.6	19	25	3.6	3.4
6.5	5.5	8	24	6.7	5.8
8.4	5.6	32	11	5.9	7.0
11.4	10.8	6	0	12.0	12.7
2.7	2.7	16	39	3.2	2.7
3.2	2.5	8	2	2.7	2.9
7.9	5.8	10	71	7.2	4.7
15.7	15.9	3	−8	14.8	16.5
6.1	4.4	4	26	6.6	5.5
11.3	6.9	12	54	10.9	7.9
8.9	7.5	6	24	8.0	6.8
9.1	6.6	11	56	7.4	5.3
5.2	4.8	33	64	6.4	5.2
10.8	10.8	8	11	10.5	10.3
4.2	3.0	33	40	3.1	3.0
5.6	4.8	13	33	4.2	3.5
7.6	5.3	17	55	7.4	5.6
4.0	2.7	9	158	5.2	2.2
8.4	8.3	−1	−12	7.7	8.7
3.1	2.9	6	93	3.0	1.7
9.8	7.8	10	60	8.7	6.0
3.8	2.2	10	−81	0.5	2.6
4.9	2.5	7	92	4.0	2.2
4.1	3.5	13	52	4.1	3.0
6.0%	**4.0%**	**11%**	**70%**	**5.2%**	**3.4%**
6.5%	**5.7%**	**10%**	**14%**	**5.9%**	**5.7%**
6.1%	**4.3%**	**11%**	**59%**	**5.3%**	**3.7%**

er companies, profit margins averaged 6.9%, up from 5.7% in second-quarter 1983.

As in recent quarters, to get these higher margins all 30 companies had to rely on more than just increased sales: Lower operating costs and improved efficiencies once again came into the picture. Celanese chairman, president, and chief executive officer John D. Macomber says of that company's 124% increase in earnings in the quarter, "Strong demand for many of our products helped us achieve this record. We also benefited from our own efforts over the past two years to permanently reduce our costs of doing business."

And Du Pont chairman Edward G. Jefferson says, "Second-quarter results reflect the continued strength of the domestic economy and the benefits of productivity and product quality improvement programs."

Add to these imposed efficiencies and cost-cutting measures the natural efficiencies gained from higher plant operating rates that follow from increased demand, and the potential for higher earnings leverage becomes clear.

Most of the trends derived from the figures for the 30 chemical companies for the second quarter also hold true for the first half. For the entire group, earnings in the first six months increased 59% from last year's first half to a total of $2.21 billion. Sales increased 12% to $36.5 billion. And profit margin rose to 6.1% from 4.3% in first-half 1983.

In comparisons by company size, the larger 15 companies outperformed the 15 smaller ones in terms of earnings growth, but lagged in sales increase and profitability. Sales for the larger companies increased an average of 12% to total $31.5 billion, and sales of the smaller firms rose an average of 13% to total $5.01 billion. On the other hand, earnings for the larger firms grew an average of 66% to total $1.88 billion, and those for the smaller companies gained 28% to total $327 million. Thus, profit margins for the larger companies averaged 6.0% in the first half, up from 4.0% a year earlier, but those for the smaller companies averaged 6.5%, up from 5.7% in first-half 1983.

In spite of the slowing in the annual growth rates in the second quarter from the first, the quarter-to-quarter results for the second quarter all showed improvement over the first quarter. For instance, second-quarter sales for the 30 firms increased an average of 3% from the first quarter, with those of the larger firms up 3% and the smaller firms 4%. Earnings for the entire group rose 11%; those of the larger firms increased 10%; and those of the smaller companies 18%. As a result, overall profit margin for the firms rose to 6.2% from 5.7%; that for the larger firms to 6.1% from 5.7%; and for the smaller firms to 6.9% from 6.1%.

The greater demand for chemical products in the second quarter was fairly widespread, according to company reports. But one of the big boosts in basic chemicals was in petrochemicals. This is amply evident in the chemical (largely petrochemical) earnings performance of some of the major oil companies.

For five of the oil producers—Exxon, InterNorth, Mobil, Shell Oil, and Standard Oil (Ind.)—chemical net earnings increased an average of 189% in the second quarter to a total of $279 million. Leading this group was a more than 10-fold increase at Shell to $58 million, followed by a 243% increase at Mobil to $24 million, a 194% increase at InterNorth to $5 million, and a 155% increase at Exxon to $135 million. Chemical earnings at Standard Oil (Ind.) climbed 91% to $57 million.

The increase for four of the firms, excluding Indiana Standard, for the first six months was even better, averaging 263% from first-half 1983 to a total of $377 million. Mobil climbed out of the red ink and recorded a profit of $32 million on its chemical operations. InterNorth's chemical earnings were up 444% to $10 million; Shell's increased 229% to $79 million; and Exxon's tripled to $256 million.

In its earnings statement, Mobil said of its chemical earnings performance, "The improvement reflected higher margins and volumes, particularly in petrochemicals, stemming from improved economic conditions and the benefits of major facilities expansions." And Shell Oil president John F. Bookout says, "The major reason for these encouraging earnings gains was sharply higher sales volumes."

The improvement in earnings extended further downstream and more broadly than just the basic petrochemicals, however. Celanese's

Earnings up substantially at both oil and diversified companies

		SECOND-QUARTER 1984						FIRST-HALF 1984					
	% chemical sales	Sales	Earnings[a]	Change from 1983		Profit margin[b]		Sales	Earnings[a]	Change from 1983		Profit margin[b]	
		($ millions)		Sales	Earnings	1984	1983	($ millions)		Sales	Earnings	1984	1983
OIL AND GAS COMPANIES													
American Petrofina	15%	$ 498.9	$ 15.7	−16%	83%	3.1%	1.5%	$ 1,046.8	$ 26.0	3%	192%	2.5%	0.9%
Atlantic Richfield	10	6,341.6	406.3	−3	3	6.4	6.0	13,083.9	801.4	2	11	6.1	5.6
Chevron	4	7,630.0	378.0	9	22	5.0	4.4	14,900.0	758.0	6	12	5.1	4.8
Diamond Shamrock	23	1,130.0	64.3	15	144	5.7	2.7	2,272.1	123.8	24	301	5.4	1.7
Exxon	7	24,307.0	1350.0	6	26	5.6	4.7	49,213.0	2825.0	6	32	5.7	4.6
InterNorth	7	1,696.8	50.7	60	57	3.0	3.0	3,696.6	184.2	53	37	5.0	5.5
Kerr-McGee	13	905.4	38.0	8	1	4.2	4.5	1,804.1	78.3	7	27	4.3	3.6
Mobil	4	14,896.0	366.0	3	−9	2.5	2.8	29,921.0	746.0	4	14	2.5	2.3
Occidental Petroleum	10	3,791.0	125.0	−18	1090	3.3	0.2	7,664.1	231.6	−19	536	3.0	0.4
Phillips Petroleum	16	4,050.0	220.0	7	61	5.4	3.6	8,010.0	413.0	8	83	5.2	3.0
Shell Oil	16	5,622.0	418.0	10	7	7.4	7.6	10,811.0	743.0	9	17	6.9	6.4
Standard Oil (Ind.)	10	7,400.0	524.0	0	23	7.1	5.8	15,000.0	1118.0	1	36	7.5	5.5
Standard Oil (Ohio)	5	3,282.0	458.0	6	−4	14.0	15.3	6,206.0	839.0	6	1	13.5	14.1
Sun	3	3,950.0	137.0	4	1	3.5	3.6	8,160.0	280.0	9	24	3.4	3.0
Tenneco	7	3,791.0	220.0	6	7	5.8	5.7	7,668.0	375.0	7	19	4.9	4.4
Texaco	4	10,500.0	302.0	6	−8	2.9	3.3	20,400.0	623.0	1	−4	3.1	3.2
Unocal (Union Oil)	11	3,000.0	185.7	7	33	6.2	5.0	5,680.0	365.8	8	37	6.4	5.1
DIVERSIFIED MANUFACTURERS													
Allied	23	2,793.0	130.0	10	10	4.7	4.7	5,596.0	263.0	11	23	4.7	4.3
Aluminum Co. of America	11	1,452.3	112.8	15	226	7.8	2.8	2,935.7	210.6	22	937	7.2	0.8
Beatrice Foods	5	2,207.0	72.0	−4	−5	3.3	3.3	4,438.0	150.0	−3	−4	3.4	3.4
Borden	18	1,186.5	51.3	9	12	4.3	4.2	2,282.8	85.2	13	25	3.7	3.4
Borg-Warner	24	1,034.7	70.8	17	57	6.8	5.1	1,982.5	121.0	17	50	6.1	4.8
Du Pont	36	9,118.0	437.0	3	61	4.8	3.1	18,371.0	810.0	5	71	4.4	2.7
Eastman Kodak	23	2,556.0	229.3	7	35	9.0	7.1	4,696.8	387.1	4	77	8.2	4.8
Engelhard	13	606.0	19.9	−2	11	3.3	2.9	1,248.7	39.9	2	17	3.2	2.8
FMC	38	939.8	64.6	7	66	6.9	4.4	1,893.2	107.1	9	52	5.7	4.1
General Electric	13	6,664.0	579.0	−1	11	8.7	7.7	13,247.0	1064.0	3	12	8.0	7.4
Georgia-Pacific	11	1,823.0	84.0	7	50	4.6	3.3	3,454.0	135.0	11	57	3.9	2.8
B. F. Goodrich	41	883.4	32.4	11	431	3.7	0.8	1,700.0	42.3	13	def	2.5	def
Kaiser Aluminum	19	988.8	32.5	28	def	3.3	def	1,775.0	47.1	30	def	2.7	def
Koppers	34	463.5	14.7	23	145	3.2	1.6	810.4	11.2	22	def	1.4	def
Eli Lilly	24	723.9	105.2	−2	3	14.5	13.8	1,618.7	251.9	3	6	15.6	15.1
3M	15	1,959.0	193.0	10	14	9.9	9.5	3,834.0	368.0	10	13	9.6	9.4
Merck	19	891.3	131.4	8	7	14.7	15.0	1,739.9	256.5	9	8	14.7	14.9
NL Industries	36	359.2	4.1	4	def	1.1	def	683.0	5.0	−5	def	0.7	def
Northwest Industries	24	496.2	23.1	23	7600	4.7	0.1	944.1	37.7	28	1994	4.0	0.2
Pfizer	11	985.7	118.1	7	11	12.0	11.6	1,905.5	245.8	4	13	12.9	11.9
Tyler	32	245.8	8.6	36	87	3.5	2.6	462.7	12.6	34	94	2.7	1.9
Uniroyal	31	614.6	36.0	13	84	5.9	3.6	1,154.5	53.1	16	129	4.6	2.3
U.S. Steel	6	4,900.0	113.0	11	def	2.3	def	9,700.0	284.0	17	def	2.9	def
Upjohn	16	581.7	47.6	12	8	8.2	8.5	1,144.7	112.7	14	26	9.8	8.9
Vulcan Materials	31	259.2	25.6	30	66	9.9	7.7	461.5	32.3	30	111	7.0	4.3

a From continuing operations excluding nonrecurring and extraordinary items. b Earnings as a percentage of sales. def = deficit.

Macomber says: "Fibers accounted for the largest share of second-quarter income, reflecting strong demand for industrial products and polyester staple." Net income for fibers at the company increased 47% in the second quarter to $1.66 per share, or about $30 million.

Monsanto's fibers and intermediates operations also did well with pretax earnings rising 57% to $33 million in the second quarter from a year earlier. For the six months, Monsanto's fibers and intermediates operations gained 143% in pretax earnings to $70 million. These results came on sales increases of 7% for the quarter to $337 million and 17% for the half to $652 million.

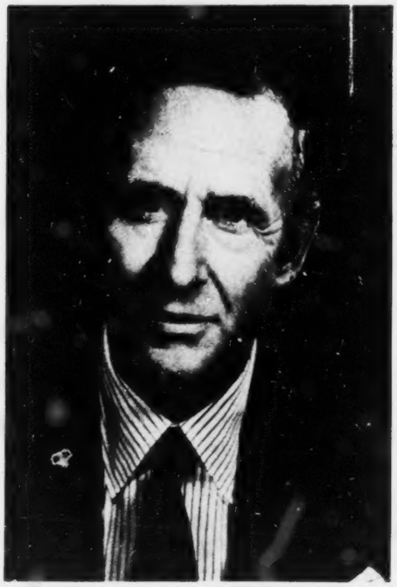
At Du Pont, fibers after-tax earnings in the second quarter increased just 11% to $102 million on a sales decline of 1% to $1.21 billion. This represents a considerable slowing from the first quarter and gives an annual increase for the first six months of 1984 of 5% in sales to $2.41 billion and a 38% rise in earnings to $204 million.

Products that go into petrochemicals also did well in the quarter. At Witco Chemical, whose earnings increased 31% in the second quarter, chairman William Wishnick attributed the results to "higher volume and stronger margins, particularly in those divisions supplying specialty chemicals to the plastics industry."

Specialty chemicals also did well at B. F. Goodrich, for which that business segment had operating income of $23 million in the second quarter, up 45% from last year. But polyvinyl chloride was the best performer for Goodrich; its pretax income rose to $28.2 million from only $2.4 million in the second quarter last year—a 1075% jump.

Agricultural chemicals—both herbicides and fertilizers—with the end of the PIK program did well. W. R. Grace says that its 42% increase in earnings in the second quarter was attributable mainly to the performance of its agricultural chemicals group, which earned $14 million in the quarter, compared with $1.6 million in the second quarter of 1983. Grace says that historically the second quarter is the strongest period for fertilizer sales, but last year's second quarter was unusually weak because of the PIK program.

At Williams Cos., Agrico Chemical's second-quarter operating profit jumped to $26.6 million from $3.3 million in the same period last year. Chairman Joseph H. Williams says, "Fertilizer volumes rose 34% above the second quarter last year, and shipments of phosphate rock increased by 9% in the same period. Prices for virtually all nitrogen and phosphate fertilizer products were also up from the same period of last year, even though phosphate margins came under severe pressure because of the late, wet spring in the U.S."



Macomber: strong demand for fibers

International Minerals & Chemical president George D. Kennedy says that the 35% increase in earnings from continuing operations reflects better volume in fertilizer tonnage shipped to domestic and export markets during the past year. However, "fertilizer volume recovery did not translate into appreciably higher price for most products." he says. "Return to adequate pricing for potash and phosphate, IMC's principal products, is being constrained by high value of the dollar, financial problems in developing countries, and slow recovery of farms everywhere."

American Cyanamid chairman, president, and chief executive officer George J. Sella Jr. says that sales and earnings of the agricultural group were significantly higher, reflecting the continuing farm recovery in the U.S.

Kennedy: better volume in fertilizer

Monsanto's operating income from its agricultural and nutritional products unit, which is made up largely of herbicides, rose 39% to $138 million in the second quarter on a sales increase of 24% to $406 million. This occurred in spite of Monsanto's statement that it held up well last year in the face of the PIK program. President and chief executive officer Richard J. Mahoney says, "Roundup and Lasso herbicides are on schedule for another good year, with favorable market performance for both herbicides." He says of the second quarter, "Demand was aided substantially by higher acreage plantings in the U.S. and generally good weather conditions around the world for the application of these two widely used products."

While glamor products such as pesticides were doing well, some other chemicals that traditionally have rather lackluster performances also were coming out of the doldrums. Chief among these seemed to be chlor-alkalies. Pennwalt chairman and chief executive officer Edwin E. Tuttle says, "I am pleased to report that caustic soda prices in the long-depressed chlor-alkali business have finally firmed. This is long overdue and we will begin to benefit from this price relief effective with the second quarter."

PPG Industries chairman L. Stanton Williams says that chlorine demand strongly led the chemical sales recovery during the quarter. Olin also singles out chlorine as having greater demand in the second quarter.

For the remainder of the year, it probably will be more of the same, although the earnings increases for chemical companies will continue to trail off as they go up against stronger 1983 quarters. However, if the U.S. markets continue to be strong, and there is further recovery in overseas markets, U.S. chemical companies will show significant earnings gains this year, perhaps as much as 40% or more. It is far from impossible. □

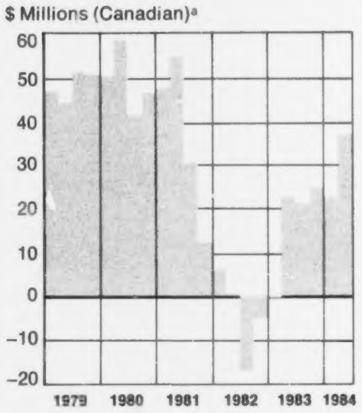
Profits Up Sharply for Canadian Chemicals

First-half results of most Canadian chemical companies continue to reflect the broad-based recovery in Canada's economy. Six-month sales are up substantially over last year and earnings have increased dramatically.

Much of the gain came in the second quarter. One indicator: Combined earnings of the four publicly reporting companies charted by C&EN (C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide Canada) hit $37.2 million (Canadian dollars throughout) in the second quarter. That's 65% better than the previous quarter, 67% ahead of the second quarter of 1983, and it is the highest quarterly earnings chalked up by the "Big Four" since the second quarter of 1981. Their combined sales, at $943 million, also was the best since the second period of 1982.

These combined results, however, mask some big differences in the performance of various companies. Although C-I-L and Celanese boosted their first-half earnings a hefty 58% and 49%, respectively, Du Pont's earnings soared 120%. And Union Carbide turned a $9 million loss in last year's first half into a $4.8 million profit this year.

Combined second-quarter earnings pushed up 37%



a After-tax earnings of four largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont Canada, and Union Carbide Canada.

Despite its apparent good fortune, Carbide still has its share of problems. The company's net income included its $8 million share of government assistance given to Petromont, the troubled, Montreal-based basic petrochemical producer that Carbide owns along with the Quebec government. That was a big factor in Carbide's $14 million turnaround in first-half earnings.

Company chairman W. Norman Kissick continues to complain about the devastating impact of taxes on feedstock and raw materials on Carbide's earnings. And, although Carbide's first-half sales increased 8% to $353 million, depressed prices in world petrochemical markets continue to be a "major earnings detractor," says Kissick.

First-half sales, earnings increased markedly

	FIRST-HALF 1984					
$ Millions (Canadian)	Net sales	Change from 1983	Net income[a]	Change from 1983	Profit margin[b] 1984	Profit margin[b] 1983
C-I-L Inc.	$ 623.6	8.1%	$22.1	57.9%	3.5%	2.4%
Celanese Canada	206.4	6.7	5.5	48.7	2.7	1.9
Du Pont Canada	608.7	11.4	27.5	120.0	4.5	2.3
Union Carbide Canada	353.5	8.2	4.8	c	1.4	c
TOTAL	$1792.2	9.0%	$59.9	182.6%	3.3%	1.3%

a Net income from continuous operations, excluding extraordinary gains or losses. b Net income as percentage of sales. c Deficit in 1983.

But Du Pont Canada's president and chief executive officer, J. Edward Newall, credits higher selling prices in both the export and domestic markets for his firm's 6.5% rise in second-quarter sales to $312 million. Six-month sales rose 11% to almost $609 million. Newall says that volume was level with last year as weak demand for nylon carpet and apparel fibers was offset by a good show of strength in consumer and industrial packaging markets. Sales of polyethylene pipe and explosives to the mining sector also were brisk.

For Celanese Canada, sales and net income in the second quarter improved only narrowly over the same period in 1983. Sales in the second quarter were up 7.8% to $107 million, but that still was better than the firm's first-quarter performance.

Celanese's earnings record, however, is a different story. Net earnings jumped 107% in the first quarter, but only 14% in the second.

C-I-L's earnings, on the other hand, were much stronger in the second quarter than in the first. The company earned $16.9 million on sales of $339 million in the March-June period, but earned only $5.2 million on sales of $284 million in the first quarter.

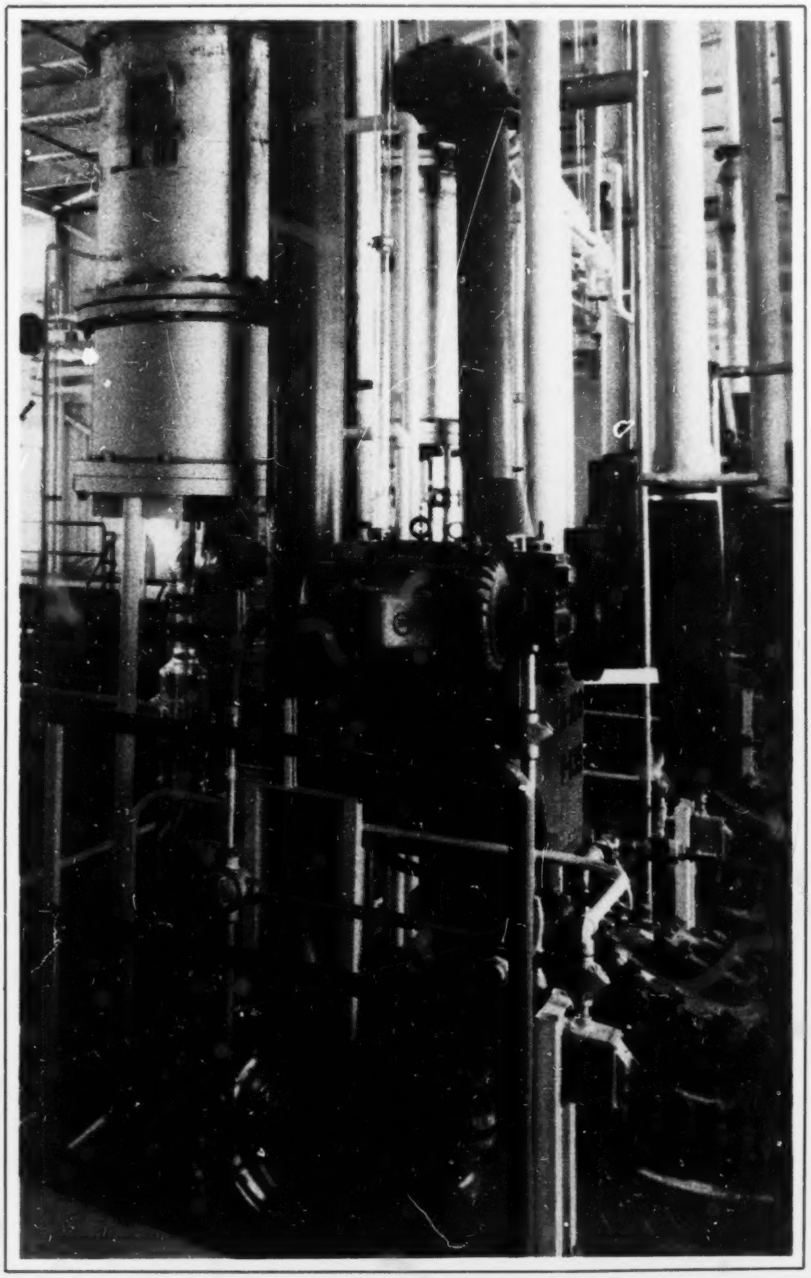
C-I-L president and chief executive officer C. H. Hantho notes that although gains in selling prices have been only modest, increased sales volume and productivity gains helped to improve operating results. Plastics sales were well ahead of 1983 as additional output became available from the expanded Edmonton plant.

Although pleased with their results so far this year, Canadian chemical companies are guarded about prospects for the rest of the year. Telltale signs of a slowdown in the Canadian economy are becoming apparent. Du Pont's Newall says, for instance, that he doesn't expect second-half results to match those of the first six months.

Earl Anderson, New York

PRODUCT REPORT

Custom Synthesis Expanding for Drugs and Intermediates



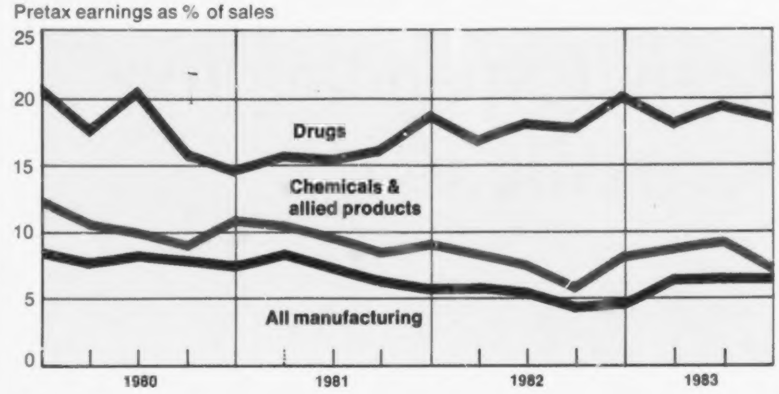
Reactors used for custom synthesis at Ganes Chemicals' Pennsville, N.J., plant

Stephen C. Stinson, C&EN New York

A 13% expansion of U.S. drug and related product sales to $33 billion this year will boost the fortunes not only of domestic drug companies but of the hundreds of firms that custom-make intermediates and bulk drugs for these companies.

Many drug companies try to produce all their needs themselves. Even at the largest drug firms, however, there may be shortages of capacity at the preparations laboratory, pilot plant, or full-scale plant. Or there may be reactions that drug companies consider too complex or dangerous. Thus, in addition to producing generic drugs such as phenobarbital or such intermediates as 6-aminopenicillanic acid to sell to many drug companies, there is a thriving if risky business for those firms making intermediates and bulk drugs that are unique to one customer.

Firms that do custom synthesis for individual drug companies come in all shapes and sizes. For example, tiny but capable firms such as Carbolabs of New Haven, Conn., and Marshalltown Laboratories of Winston-Salem, N.C., can run three 22-L flasks side by side to make a year's supply of 5 to 25 kg of an intermediate for a drug that is in its early stages of development. At the other end of the scale, dedicated units at such companies as Ethyl Corp. at Baton Rouge, and Tennessee Eastman at Kingsport, Tenn., turn out the 3000 to 5000 kg per



Profitability of U.S. drug sales leads that of all industry

Source: Bureau of the Census

year that an average drug needs that has just hit its marketing stride.

The world of custom synthesis is aswirl with changes. Some companies get fed up with juggling the many projects needed to succeed and turn their backs on it. Others see great potential in the business and can't wait to elbow their way in.

Among the firms that have had second thoughts about custom synthesis are Syntex Chemicals, J. T. Baker Chemical, Parke-Davis division of Warner-Lambert, and Pfizer.

Syntex Chemical began its cutback three years ago. The company still seeks business in custom synthesis, according to sales manager Al Wilson, but only where it is a good fit in chemistry and equipment. Much of the capacity once used for custom synthesis has been devoted to needs of the parent drug company, Syntex Corp.

J. T. Baker got into custom synthesis in 1981 as a way to use capacity freed after its parent company, now called Richardson-Vicks, sold Merrell Pharmaceutical to Dow. But a spokesman for Baker says that the company now prefers to use the capacity for its own product line, which it sells to many customers, rather than be dependent on the downstream fortunes and marketing abilities of one customer. The company still produces for a few selected customers but does not seek new business.

Similar thinking guided Parke-Davis, says marketing and new product planning manager John Controulis. The company hoped for long-term contracts for custom synthesis, he says, but these never developed. Thus, although the company's contracts of 50 to 200 kg per year of drug, food, and cosmetics compounds were profitable, the question arose of how best to use available capacity. Seeing a few of its own new drugs in the pipeline, and wishing to make sure enough capacity would be available for them, Parke-Davis stopped serving all but one isolated customer in July.

But sometimes the withdrawal of one firm can mean the appearance of another. Pfizer spun off its special chemicals department in Greensboro, N.C., to a group of its employees in April. The main business of what is now Morflex Chemical Co. is vinyl plasticizers. But president Gary F. Taft says that the new firm also makes a few custom ester drug intermediates. Another of the company's specialties for the drug industry is custom sulfonation of aromatics followed by alkali fusion to phenols.

Albany International also sold off its chemicals division in Columbus, Ohio, to Essex Chemical Corp. in 1983. Essex was attracted by the division's custom synthesis business, which it hoped to use to get into the field. Albany originally bought the division as Chemsampco to make insect pheromones to go with its pheromone dispensing technology but found it not very profitable.

All segments of U.S. drug market are growing

$ Millions	U.S. consumption	Exports	Imports
ANTIBIOTICS			
1982[a]	$ 1,820	$ 730	$ 160
1981	1,560	710	180
1980	1,330	640	120
1979	1,100	530	120
1978	1,030	450	110
BIOLOGICALS			
1982	1,250	430	30
1981	1,200	360	30
1980	1,070	370	20
1979	930	280	10
1978	850	170	10
CENTRAL NERVOUS SYSTEM DRUGS			
1982	4,020	100	130
1981	3,490	120	120
1980	3,090	90	120
1979	2,930	70	80
1978	2,490	80	80
ENZYMES AND FERMENTS			
1982	320	40	90
1981	310	40	90
1980	270	40	70
1979	250	40	60
1978	230	40	50

$ Millions	U.S. consumption	Exports	Imports
HORMONES			
1982	$ 1,150	$ 210	$ 80
1981	980	210	70
1980	850	190	60
1979	790	170	50
1978	780	160	50
VITAMINS			
1982	1,580	110	150
1981	1,440	90	190
1980	1,380	70	160
1979	1,230	60	150
1978	1,030	60	140
OTHER[b]			
1982	14,690	710	400
1981	12,650	670	370
1980	10,600	610	400
1979	9,510	510	420
1978	9,460	530	420
TOTAL[c]			
1982	$24,830	$2320	$1050
1981	21,610	2230	1050
1980	18,620	2000	960
1979	16,740	1660	890
1978	15,880	1480	860

a Latest year for which data are available. b Includes anti-infective, gastrointestinal, autonomic, cardiovascular, hematological, and anticancer drugs; antihistamines; and smooth-muscle relaxants. c Items may not add to totals because of rounding. **Source:** U.S. International Trade Commission

Essex has re-erected the division as its custom synthesis subsidiary, Orsynex, and installed Kenneth Houle as president. Houle emphasizes that he operates at arm's length from another newly acquired Essex subsidiary, Pioneer Pharmaceuticals, makers of generic drugs. Drug companies are sometimes reluctant to reveal details of new drug candidates to custom manufacturers who are too closely tied to other drug companies.

Another new entrant to custom synthesis is Union Carbide Corp. The company's process systems and services department will use the preparations laboratories and pilot plant at South Charleston, W.Va., to make amounts ranging from kilograms to tons. Carbide business manager B. I. "Woody" Friedlander estimates that the total U.S. market for custom synthesis is $500,000 per year, with an annual growth rate of 8 to 12%. Of this amount, drugs, pesticides, and their intermediates comprise perhaps 85 to 90%, with drugs and their intermediates slightly greater.

This relatively large market and growth rate for custom synthesis has not escaped the notice of European and Japanese chemical companies. Market researchers at Eastman Kodak say the U.S. market for such services is larger than in other areas of the world and growing at a faster rate. This situation, combined with a strong U.S. dollar that cheapens imports, has led foreign suppliers to add sharp price competition to their long-standing aggressiveness based on quality.

Foreign firms market custom synthesis in the U.S. through their U.S. subsidiaries or through agencies. For example, Mobay Chemical Corp. offers custom synthesis domestically and can refer projects to its parent, Bayer of West Germany. Peter Benzing, general manager of Mobay's organic and rubber chemicals division, says the tie with Bayer gives drug firms the two sources of supply desired for intermediates going into commercial drugs. It also gives multinational drug firms sources of supply on two continents.

Among agents that represent foreign firms are Henley & Co., New York City, and S.S.T. Corp., Clifton, N.J. Both companies also have U.S. clients. Henley's overseas clients offering custom synthesis to the drug industry include Finorga of France and SSF Dottikon of Switzerland.

To be successful attracting drug industry business, a company must have capabilities to run uncommon or dangerous processes, says Lester LaGrange, Henley's manager of technical sales. For example, Finorga has a cryogenic reactor for Birch reductions and selective oxidations. SSF Dottikon does nitrations, which are dangerous on a large scale.

S.S.T. Corp. arranges custom synthesis as an offshoot of its regular business, which is distribution of imported intermediates and bulk drugs from inventories in the U.S. Faced with a request for an exotic intermediate, the company searches among its clients and other firms. Sometimes the intermediate is available commercially, a spokesman says, but so little in demand as to be unadvertised. If unavailable, S.S.T. looks for companies with the right chemistry and the willingness to make the small initial amounts needed. The hope is that these small projects will mature into big ones, and the spokesman says that S.S.T. brings four to five such projects a year to this final stage.

In a switch on the usual routine, one U.S. company plans to offer custom synthesis to the drug industry from an overseas plant. Angus Chemical Co., Northbrook, Ill., will open a $13 million plant in Ringaskiddy, Ireland, in 1985, as a joint venture owned 20% by Isochem of France. Angus president Wayne Chandler says the plant will be able to do such hazardous processes as bromination, high-pressure hydrogenation, nitration, phosgenation, and reactions with carbon disulfide and dimethyl sulfate. He explains that Angus decided on a joint venture route because of Isochem's process know-how and marketing skills.

The person at a drug company that all of these hotly competitive firms try to reach often has the title of director of process engineering. This director is located within the research department and manages the "prep" or "kilo lab" and the company's pilot plant. He or she guides the production of a drug candidate through the first few kilograms needed for acute and 90-day toxicity testing, gathering information to apply to pilot production. The director scales up the process to the pilot plant, if the company has one, which makes 50 to 200 kg per year for clinical tests. After as

Union Carbide's custom synthesis plant in South Charleston, W.Va.

Custom synthesis: how one drug firm would arrange it

Process engineers at drug companies have their own systems of searching for sources of bulk drugs and intermediates. Their task is often difficult, because there are many large firms that would be willing to make several kilograms and large companies interested in 1000-kg or 10,000-kg orders. Relatively few firms serve the gray area of 50- to 200-kg quantities, and their number grows smaller for unusual chemistry or complex syntheses. C&EN asked one director of process engineering to describe his system for obtaining a source to custom-synthesize a drug or intermediate. Because he names firms he would go to in his search, he asks not to be identified.

He collects literature and catalogs of chemical firms and files them by the type of chemistry each can do and compound types each works with. He has catalogs of flavor chemical producers, because the heterocyclic rings of many of these are similar to those of drugs. He collects literature from monomer producers, because the chemistry may match what he seeks.

His company's purchasing department sometimes gets involved, but the work usually falls on him. In urgent need of a few kilograms for 90-day or acute toxicity testing, he would go to Carbolabs or Marshalltown Laboratories. He also cultivates chemistry professors in his areas, because they are often willing to make 100 to 1000 g of a needed compound in a hurry.

As greater amounts of compound are needed for chronic toxicity and clinical testing, he would seek out a company whose plant is approved by FDA as following good manufacturing practices (GMP). This is because the company he chooses might end up making commercial amounts of the drug, and he could stay on with the same supplier. Such companies he mentions are Hexagon Laboratories, Johnson Matthey, Orsynex, Quality Chemical, and Upjohn.

If one or more steps in the synthesis prove too exotic or dangerous for the GMP firm, he might seek out a non-GMP company to carry the drug to an advanced intermediate and supply it to the GMP firm as raw material. At about this time, he also would communicate with all the agents he knows to let them know of his need for the intermediate. Such agents include Austin Chemical, Chemical Dynamics, Henley, Interchem, and S.S.T.

As the drug nears FDA approval, if his company decides to continue custom synthesis on a larger scale, he will try to stay with the same GMP supplier. He might go so far as to write specifications around that supplier's capabilities. But, he says, his company's purchasing department sometimes disagrees and insists on putting the project out more generally for competitive bidding.

long as 10 years, when Food & Drug Administration approval is imminent, upper management makes a decision to add units to the company's own commercial-scale plant or to assign the active drug compound to an outside vendor.

But the prep lab or pilot plant may be backed up with work. The company might not have a pilot plant. One of the intermediates may involve a dangerous reaction or such expertise as fluorine chemistry, unavailable within the company. The company might have limited or no commercial production capacity. Or management might decide not to add a dedicated, full-scale production unit until the drug has proved itself in marketing. Each of these eventualities offers opportunities to custom synthesis firms.

Directors of process engineering at drug companies are proud of being good at what they do. They stress the importance of fair dealing and constant and open communication between themselves and their suppliers of custom synthesis. LaGrange of Henley comments that, "A good manager of a kilo lab spends a quarter of his time talking to suppliers."

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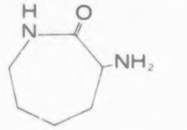

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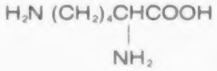

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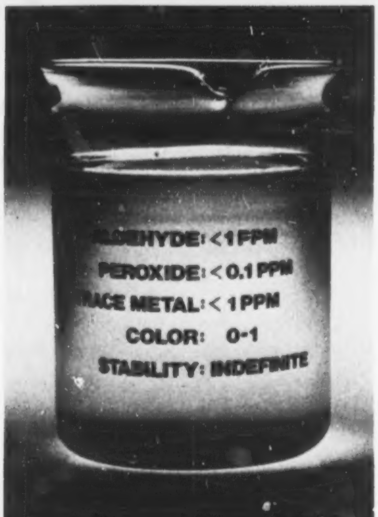

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Says Donald Kuhla, director of process engineering at William H. Rorer, in Fort Washington, Pa., "I try to work out a rapport, a relationship, so that [suppliers] will tell me that [they're] full-up and can't respond for two months."

For his own part, Kuhla says, "You can't shop the same project out to 12 [firms] for 50 or 100 kilos each. It's like crying 'wolf.' You can do it once or twice. [Custom synthesis firms] will try it without making any money on it, thinking to make it up later when the big orders start coming in. You only need 50 to 100 kilos a year, not only for the 10 years it takes for FDA to approve the drug, but for three to five years after that till the drug hits its market share. So people have to be convinced to go on making it for a long time in hopes of finally making money. It's very important to be up-front and honest with people, because they don't do more than cover costs."

Like most people in his position, Kuhla tries to arrange two sources of supply for security. With this, also, he stresses honest dealings. "Most drugs at maturity amount to only 3000 to 5000 kilos a year. So while the value added is high, volumes are low. We always try for two suppliers, but if the weight of the drug is only 3000 to 5000 kilos a year, you're not doing anybody a favor by qualifying more."

Factors that affect selection of a firm for custom synthesis include financial stability, past dealings, experience with the chemistry or compound type involved, reliability, fast response to a request for a price quote, and familiarity with any dangerous reactions to run them safely. If the drug company has the bulk drug made outside, it is important to have an FDA-approved laboratory from the beginning, so as not to have to shift gears at the end of development. But the most important factor is environmental. Drug companies' reputations can ride on an outside vendor's responsible disposal of waste.

"We investigate potential suppliers extensively, particularly in the environmental as well as the usual financial areas," says Robert J. Dille, director of purchasing at Eli Lilly &

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ACS division to hold symposium on custom manufacture

Both managers of process engineering for drug companies and managers of firms that offer custom synthesis find sessions of the American Chemical Society's Division of Small Chemical Businesses useful in making and keeping contacts, says Donald Kuhla, director of process engineering for William H. Rorer Inc. In this connection, the Philadelphia ACS meeting will be especially useful. The division will hold a symposium on custom manufacturing on Wednesday, Aug. 29, at 9 AM in the Civic Center.

The symposium was organized and will be chaired by J. Paul Raycob, vice president of Ennis Chemical Co. W. Bryce Anderson, president of the parent company, Ennis Industries, will speak on financial aspects. Roger L. Logan, assistant to the general manager of the chemical products division of Union Camp Corp., will give guidelines to those searching for toll producers—those who use raw materials supplied by their customers. Joseph Abelson, marketing manager for ICI America's specialty chemical division, will talk about marketing. And Nicholas Prato, manufacturing manager for McWhorter—a producer of resins for the coatings industry—will discuss manufacturing.

According to Logan, the major criteria in evaluating a toll supplier are reliability, environmental problems, and safety. He says that decisions on toll manufacturing should depend on answers to a number of questions: Have the options for making the new product in-house been thoroughly explored? Has the supplier worked on similar projects with positive results? Does the supplier have 24-hour manpower coverage for plant operations and the laboratory? Is the intended process or product proprietary or patentable? Will the toll producer try to compete in the merchant market when the contract expires? What percentage of the toll producer's capacity will be used? If the toll producer improves the process or product, who owns the improvement? Can the toll producer package the product to meet market demands?

In his presentation, McWhorter's Prato divides manufacturing into raw materials, processes to be used, and finished products. Of raw materials, Prato plans to discuss suppliers' reliability, shipping capability and lead times, and ability to maintain minimum and maximum inventories. Other important considerations include quality control tests, whether new testing equipment will be needed, logistical and regulatory aspects of handling and storage, shelf life, mutual compatibility of chemicals, proper labeling under worker right-to-know laws, and disposal of waste. When using a new raw material, the custom manufacturer must also review existing plans for such emergencies as spills.

When studying the process, Prato says, the custom manufacturer must consider its safety, time and labor requirements, time and costs of cleanups between batches, and compatibility of chemicals with equipment. For the final product, the issues are quality control, handling, legal aspects of storage, and compatibility with storage vessels.

Co. (Despite his title, Dille came up through process engineering, as did the two purchasing agents who work for him.) "Environmental concerns are what make it so hard to choose among so many companies. Small companies often don't have their own waste disposal or solvent recovery facilities. They have to send it out. That's risky. So we worry about that."

Fast response on a price quote can be important. Fast means as short as one week to study the process, decide on its feasibility, and quote a price per kilogram. Several large firms do respond rapidly, according to a number of process engineering directors. But they also point out that one large firm, otherwise favored as thorough, cautious, and reliable, could, as one director quipped, "take three months to decide whether to sign a secrecy agreement. In that time, we've got a quote from someone else, he's developed the process, and we've taken delivery on the first few kilos."

Process engineering directors don't always agree on sending work

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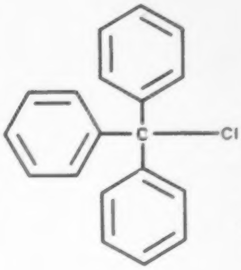
to other drug companies. Hoechst-Roussel Pharmaceuticals, Somerville, N.J., has its cephalosporin antibiotic cafotaxime made by Baxter Travenol of Deerfield, Ill., because the company lacks a fermentation plant in the U.S. But the worldwide facilities of the parent Hoechst (of West Germany) are otherwise so vast, a spokesman says, that the New Jersey company never has to buy custom synthesis outside.

One drug company that asked not to be named has a strict rule against dealing in this way with other drug firms, unless the other firm has developed the drug, licensed it, and insisted on producing it for the first few years. Dille says that Lilly would use another drug company, subject to proper secrecy agreements, but not if the other company marketed drugs competitive with the Lilly compound. William Welstead of A. H. Robins Co. agrees that there are risks sending work to other drug companies, but adds, "These others couldn't stay in that business long without observing proper business procedures."

But these directors also agree that a company like Mobay, for example, does not count as "another drug company." They feel that Mobay operates sufficiently distant from the drug operations of Bayer and of Bayer's other U.S. subsidiary, Miles Laboratories.

There is also difference of opinion about the wisdom of dealing with overseas firms. "We've talked with representatives of European companies over the past few years," says Vasken Paragamian of McNeil Pharmaceutical, in Fort Washington, Pa., "but no projects have resulted. There are problems of communications, tariffs, and closeness. I always ask them, 'What can you offer me? Why should I do business with you?' They answer 'Quality.' But there haven't been any opportunities so far." Paragamian's concern is that detailed technical discussions are needed with an outside supplier in the first stages of process development.

That is just when companies that offer custom synthesis to the drug industry would like drug firms to bring them in—at the earliest stage of a drug's development. Their hope



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is that their growing expertise in producing the drug or advanced intermediate, combined with the FDA requirement of a Drug Master File, will lock the business up for them when the drug is approved.

A Drug Master File is a document that includes descriptions of all producers that work on the drug and its intermediates, as well as all raw materials, reactions, processes, equipment, analytical procedures, and expected by-products at each step. Once an outside supplier and its process have been filed in this way, it is very difficult to change. Moreover, outside suppliers often can keep details of their process improvements secret, even from the drug company customers. Outside suppliers can patent some processes. Thus, although an outside supplier will give a Drug Master File to FDA as a part of the drug company's submissions, it can ask that the file be kept confidential, even from the company whose drug it covers.

Process improvements by outside suppliers lower their production costs of drugs and their intermediates. This cost advantage can become so great by the time FDA approves the drug that it can be difficult for a new company to compete as a second source. As Lilly's purchasing manager Dille puts it, "A competitor must have developed absolutely new chemistry to take the business away. From a purchasing standpoint, it's hard to know if you have a good deal or not, because competitive bidding is limited by the nature of the situation."

But if the earliest stages of drug development have the greatest potential for future profit from commercial-scale orders, they also pose the greatest risks. There is a certain mortality among new drug candidates and even among newly approved drugs. For example, unexpected side effects may appear at any stage. A drug may fail to live up to its market potential. Or a drug company may take production of a newly approved drug in-house. A custom supplier may not have produced enough drug or intermediate to cover process development costs.

There are different arrangements to cover process development costs. Some custom synthesis firms ask for and get advance payment for developmental work. Drug companies tend to resist this arrangement, and some directors of process engineering say they can hold out until they find a supplier willing to accept another arrangement. Still, some contracts call for a price for development and a 100-gram sample of product. For a process known only from a drug company's laboratory work that produced a few dozen grams, the drug company may agree to a fixed fee for scaleup and take whatever yield results, from 0 to 100%.

The most common arrangement,

Continued on page 52

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however, is for the custom supplier to estimate development costs and fold them into the price per kilogram over a three- to five-year contract. This can result in prices of $2000 to $10,000 per kg, but in developmental stages, drug companies are more concerned with reliable supply than price. This arrangement involves risk, however, that a project may be canceled before the custom supplier has recovered process development costs.

In such cases, Orsynex president Houle says that the drug firm usually compensates the custom synthesis firm to avoid losses. But market researcher Carol M. Apuzzi of Ganes Chemicals, New York City, says that Ganes simply runs the risk of such a loss.

Development costs of custom synthesis firms can include those for preparing the premanufacturing notice (PMN) that must be supplied to the Environmental Protection Agency under the Toxic Substances Control Act (TSCA). Research amounts of a new drug or intermediate are exempt from TSCA, but the 50 to 200 kg-per-year amounts for clinical tests require a PMN.

Philip St. George, marketing specialist at Kodak Laboratory & Specialty Chemicals, says that Kodak usually prepares the PMN and asks the drug company customer for data needed for it. He adds that Kodak also has its Safety & Human Factors Laboratory to get environmental and toxicity data that may be lacking. Benzing of Mobay says its drug company customers usually prepare the PMNs.

Drug companies differ in their needs for custom synthesis and thus in the opportunities they offer to those who purvey it. Smaller drug companies, for instance, have drug discovery research groups, kilo labs, no pilot plants, and limited or no commercial production capacity. Medium-sized companies have a pilot plant in addition. Larger companies have extensive commercial-scale plants as well.

Among the larger companies there is also the management philosophy to consider. Some large companies prefer to make everything in-house, from discovery through commercial production. Others routinely farm out advanced intermediates, because they prefer not to devote their resources to process development. After FDA approval, they might still buy the advanced intermediate outside, until the success of a drug in the marketplace justifies adding dedicated units for it to their own plants. But all large companies do the last one or two steps of drug production inside.

A. H. Robins serves as an example of how a small drug company operates. The firm produces on a commercial scale for itself through Lee Laboratories, Petersburg, Va., which it owns jointly with Boehringer Ingelheim of West Germany. Of the two dozen organic active

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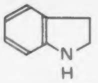
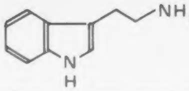
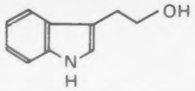
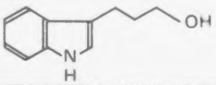
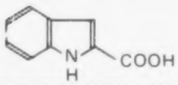
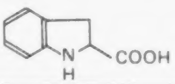
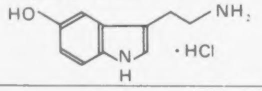
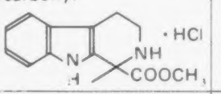
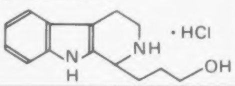
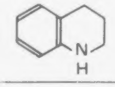
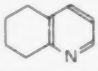
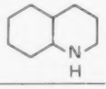
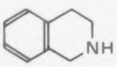
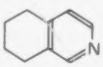
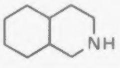
Indoline 	Tryptamine 	Tryptophol 
Homotryptophol 	Indole-2-carboxylic acid 	Indoline-2-carboxylic acid 
Serotonin hydrochloride 	1-Methyl-1-metoxycarbonyl-tetrahydro-β-carboline hydrochloride 	1-Hydroxypropyl-tetrahydro-β-carboline hydrochloride 
1,2,3,4-Tetrahydroquinoline 	5,6,7,8-Tetrahydroquinoline 	Decahydroquinoline 
1,2,3,4-Tetrahydroisoquinoline 	5,6,7,8-Tetrahydroisoquinoline 	Decahydroisoquinoline 

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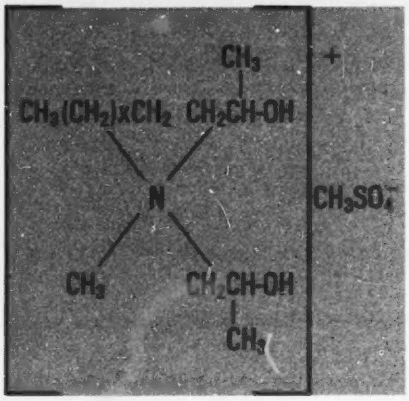

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ingredients in Robins' prescription drugs, Lee makes doxapram, guaifenesin, methocarbamol, metoclopramide, phenylephrine, and polycarbophil calcium. The weight-loss drug fenfluramine may be custom-synthesized outside. The rest are generics that the company buys.

A custom synthesis firm that lands Robins' business to make a newly discovered drug has a good chance of staying with the firm through commercial production. As Robins' Welstead explains, "We always go to Lee first with a commercial drug. Sometimes they can produce it for us. More often, they can't." But a custom synthesis firm has to be nimble to deal with Robins. "We have to be fast and flexible," Welstead says. "That's how we can compete with the giants."

Things go a little differently at medium-sized drug companies such as McNeil. The firm has a pilot plant and, as a subsidiary of Johnson & Johnson, has access to some commercial production resources within that company. Thus by the time a custom synthesis firm is called in to bid on a McNeil drug or advanced intermediate, Vasken Paragamian already has developed the process in the pilot plant, and approval is estimated to be only two to three years away. This means that the risk of staying through perhaps 10 lean years of development with the ever-present possibility of sudden death is absent. But the outside firm is now trying to come in as low bidder and one of two qualified suppliers.

There are opportunities, however, for custom synthesis firms to do dangerous reactions for McNeil even in development years. Because the pilot plant is in a residential community, Paragamian will not consider high-pressure hydrogenation, nitration, phosgenation, or use of cyanide salts there.

At large companies such as Parke-Davis, almost the only opportunities for custom suppliers are tolling of intermediates through one hazardous step during development years or production of anticancer drugs. (Tolling is use of raw materials supplied by a customer to produce a product for the customer.) Even in the field of cytotoxic anti-

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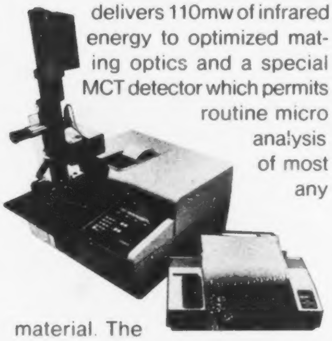

cancer drugs, the company already has installed facilities to test small amounts of such substances safely. Marketing manager Controulis says it is rare for the company's kilo lab or pilot plant to be backed up with work. Drug development occurs on such a long time scale, he says, that there is plenty of time to consider pilot plant expansions and prepare for commercial-scale production. And when it comes time to add dedicated units to the full-scale plant, Parke-Davis would do even potentially hazardous reactions in-house.

Dille indicates the situation is similar at Eli Lilly. That company has been more flexible in the past about ordering synthesis of advanced intermediates outside. But now the tendency is to make even the intermediates in-house, as far back as possible. "But how far back can you integrate?" Dille asks. "So we always find ourselves purchasing some unique intermediate."

One possibility is that the research group may invent new chemistry that doesn't fit in with Lilly's production capability. Or production may involve an established branch of chemistry that Lilly hasn't mastered. For example, Dille says the company's research turns up increasing numbers of fluorine compounds, and Lilly doesn't have chemists with expertise in or equipment that can handle fluorine chemistry. However, he says the company is considering adding these. "But we do not farm out anything at all because of safety or environmental reasons."

In addition to making drugs by organic synthesis, Lilly also produces antibiotics by fermentation. "We never farm out fermentation," Dille declares. "We have done it rarely in the past when we were out of capacity, but that won't happen in the future. . . . We ourselves would be on the lookout for custom fermentation business."

One characteristic shared by almost all custom synthesis firms is that they have other businesses to fall back on. Most often, custom synthesis grows out of the other business, as was the case of the photographic chemicals and laboratory reagents of Kodak. Or companies in custom synthesis develop the other

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WEDNESDAY EVENING, December 12, 1984—Registration & Welcoming Reception

THURSDAY MORNING, December 13, 1984—*Ordered Polymers*: J. Economy, General Chairman (Opening Remarks); G. Berry, Presiding (Introduction and Overview); P. J. Flory, Stanford University, "Thermotropic Liquid Crystalline Materials"; C. L. Choy, The Chinese University of Hong Kong, "Thermal Conductivity and Expansion of Oriented Polymers"; D. G. Baird, Virginia Polytechnic Institute, "Structure & Morphology Development in Thermotropic Systems"; G. Berry, Panel Discussion.

THURSDAY EVENING, December 13, 1984—*Polymers as Ceramic Precursors*: K. Wynne, Presiding (Introduction and Overview); R. West, University of Wisconsin, "Polysilane High Polymers and Their Technological Applications"; K. Okamura, Tohoku University, "Polycarbosilanes: Preceramic Polymers"; K. Wynne, Panel Discussion.

FRIDAY MORNING, December 14, 1984—*Advanced Matrix Materials*: N. Johnson, Presiding (Introduction and Overview); E. J. Kramer, Cornell University, "Network Effects on Deformation of Glassy Polymers"; R. L. vanDeusen, Wright-Patterson Air Force Base, "Synthesis & Characterization of Higher Performance Structural Materials"; A. F. Yee, General Electric Company, "Micro Macroscopic Approaches to Tough Plastics"; N. Johnson, Panel Discussion.

FRIDAY EVENING, December 14, 1984—*Polymer Division Award Address*: G. L. Donaruma, Presiding; W. Stockmayer, Dartmouth, "Perspective on Contributions of John D. Ferry to Polymer Science"; J. D. Ferry, University of Wisconsin, "Fibrinogen—A Megabiomonomer; Fibrin—A Hyperbiopolymer"; Polymer Division Award Reception and Dinner.

SATURDAY MORNING, December 15, 1984—*Radiation Sensitive Polymers*: M. J. Bowden, Presiding, (Introduction and Overview); J. H. O'Donnell, University of Queensland, "Mechanism of Degradation of Radiation Sensitive Polymers"; C. G. Willson, IBM Research Laboratory, "Chemical Amplification in Polymeric Imaging Systems"; M. Hasegawa, University of Tokyo, "Topochemical Synthesis and Photochemical Behavior of Radiation Sensitive Polymers"; M. J. Bowden, Panel Discussion.

business, like the line of generic drugs Orsynex plans to produce.

Kodak's St. George says the company got into custom synthesis as a result of continuous inquiries from drug company researchers for 5 to 100 kg of compounds they previously had bought in small amounts through the catalog. "We see custom synthesis as a natural tie-in with photographic chemicals," says St. George. "We've developed the skills to go from the laboratory to commercial scale," he adds, pointing to the wide variety of chemical reaction types used to make photographic chemicals.

One weakness in custom synthesis at Kodak, however, is that the company limits the types of reactions it will carry out. It does some phosgenations and Grignard reactions, but it will not do high-pressure hydrogenations, polynitrations, or lithium aluminum hydride or Birch reductions, for example.

Another company that grew into custom synthesis from another business is Hardwicke Chemical Co., Elgin, S.C., a subsidiary of Ethyl Corp. since 1978. President James Hardwicke founded the company in 1967 to make intermediates for synthetic pyrethroid insecticides. A Hardwicke specialty today is bromination, but it does no other dangerous reactions. Hardwicke says that most of the company's equipment is geared to liquid chemicals, but he will install more solids-handling units as the company expands more toward servicing the drug industry.

Houle of Orsynex intended from the beginning to offer a combination of unusual and dangerous reactions. The only dangerous reaction Orsynex will not take on is nitration. Its Essex parent made a couple of false starts entering the custom synthesis business. It first acquired Minerec Corp., Baltimore, in 1979, which makes phosgene among its products. But the plant there could not be upgraded to the desired level. In 1981, Essex began operating the South Haven, Mich., plant of Wyckoff Chemical Co., but ended that arrangement, too. Acquisition of the Columbus plant finally set the company on the road to its goal. □

Chicago museum exhibits
"Everyday Chemistry"
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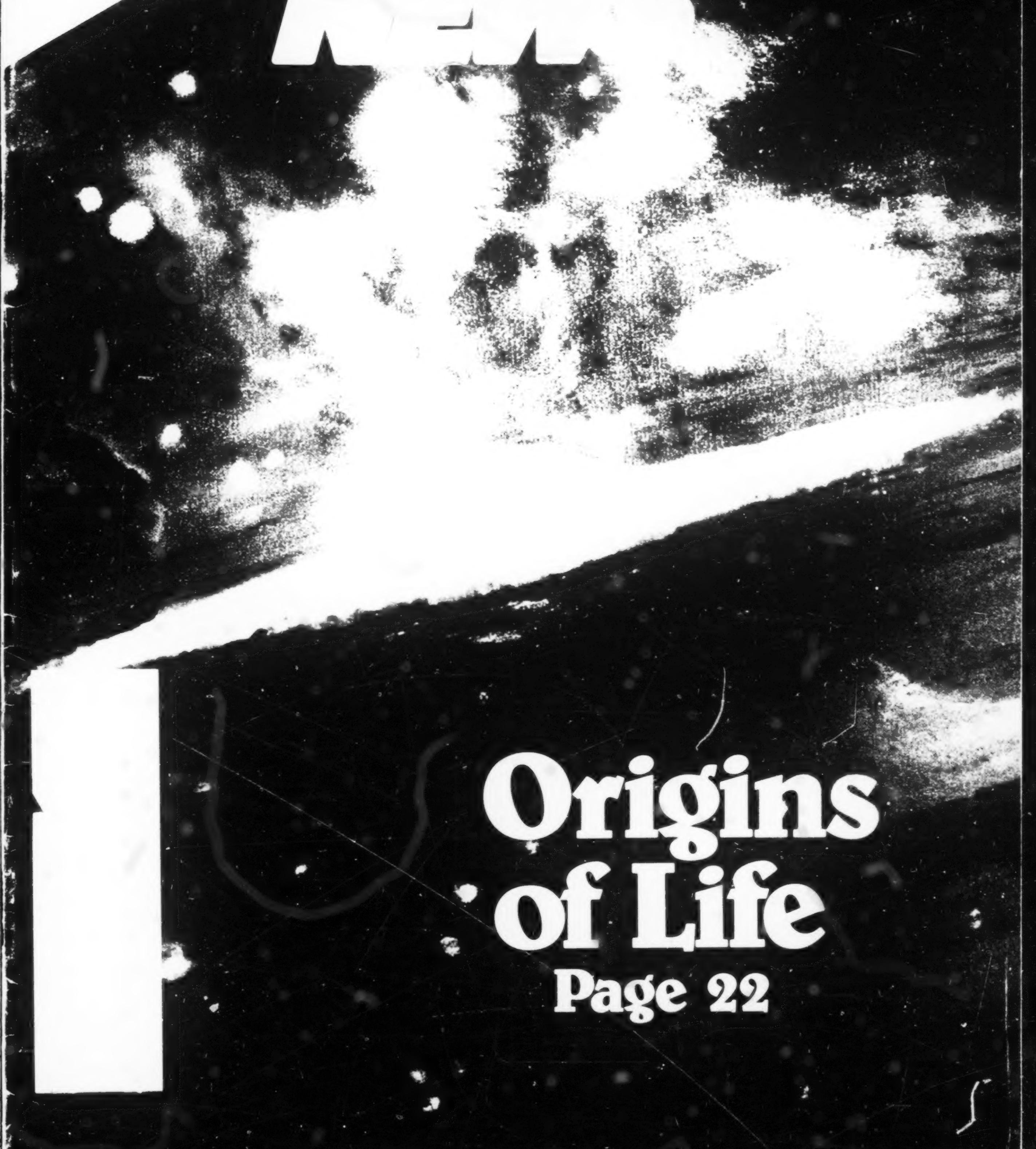
AUGUST 27, 1984

CHEMICAL & ENGINEERING

NEWS



Origins of Life

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CHEMICAL & ENGINEERING
NEWS

Volume 62, Number 35
CENEAR 62 (35) 1–56
ISSN 0009-2347

AUGUST 27, 1984

News of the Week

- **EPA begins two-year study of toxic substances in California's Santa Clara Valley.** Page 3
- **ICSU committee recommends 100-year wait before disposing of nuclear wastes permanently.** Page 3
- **ICI offers consulting service to improve energy efficiency in process plants.** Page 4
- **New technique improves efficiency of human monoclonal antibody production.** Page 4
- **Foreign gene has been expressed in soybean cells transformed by recombinant DNA technique.** Page 5
- **Chemistry olympiad medalist Seth Brown honored in Pittsburgh.** Page 5

Cover: Cloud of interstellar dust and gas from which our solar system was formed is illuminated by the newly formed sun in painting by John A. Wood, Center for Astrophysics, Harvard College Observatory

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Business

U.S. pharmaceutical firms raised profits 13% in the second quarter over 1983; pigmented plastics costs will rise. **Page 9**

International Business

Union Carbide Europe boosted earnings by dropping petrochemicals to concentrate on specialty, service-oriented markets. **Page 11**

Government

Congress worked on a number of appropriations, environment, and patent bills during session between conventions. **Page 14**

Education

Chemistry exhibit at Chicago's Museum of Science & Industry shows basic principles in everyday use, hands-on experiments. **Page 18**

Science

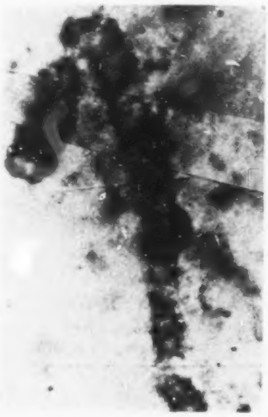
Beilstein Handbook of Organic Chemistry will go on line in 1987, supplementary series will switch from German to English. **Page 20**

Science Issues

American Scientific Affiliation aims to resolve conflicts between science and Christianity, humanize science and society. **Page 36**

Books

"The Man-Made Sun" details pressure, controversy, and politics behind the development of fusion power in the U.S. **Page 39**



Special Report

From an understanding of how the solar system was formed, scientists have determined the conditions under which life probably originated on Earth and, by experiment, have demonstrated a number of possible theories. **Page 22**

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LETTERS

Methanol in the fuel market

SIR: Congratulations on your recent article on methanol in the fuel market which appeared in the July 16 issue, page 9. I think it is by far the most accurate and concise summation of the business conditions surrounding this industry that I have read to date.

United American Fuels has sold millions of gallons of methanol blends into the fuel market since the company was started in April 1983. Our experience has been that the product has received far more positive comments and responses from our customers, as well as their customers, than negative feedback. This condition exists in spite of negative publicity which is touted by some major oil companies in full-page ads pointing out the negative aspects of the product. Proper blending, coupled with rigid quality control and station preparation, can and has overcome these negative aspects.

I think the fact that sales remain healthy is the best testimonial to the efficacy of the product. If it were not well received, our free enterprise system would have ensured its demise long ago.

John P. Simion, *President*
United American Fuels, Phoenix

Another look at creationism

SIR: I have not read "Science and Creationism" edited by Ashley Montagu and have little intention to do so. I have read, however, the book review by Rudy M. Baum, your West Coast Bureau Head (C&EN, July 9, page 41), and note that, while he is not fully satisfied with the hatchet job done on Mr. Montagu in respect to organization of the material, his views on creationism are equally one-sided.

Fortuitously I was not around at the time of the "Big Bang" and the "Creation," but neither was Montagu nor your Baum. Over the years I have studied the writing of innumerable authorities of biology, cosmology, religion, philosophy, history, and anthropology on the origin of life. I realize that there have been dozens of varying and often conflicting theories ranging from thick primordial broths, devoid of any guiding hand, to an all-encompassing knowing creator. Unfortunately, in addition to Montagu, your Baum, and me, none of the thousands of great thinkers of the past were around either when the "Big Bang" happened and life started. We and our heirs, therefore, will have to continue speculating, theorizing, and conjecturing how it all came about.

In the meantime, I turn with disgust from the smug cocksureness of Montagu as well as of your reviewer who, by ignorance or design, tend to rebuke and vilify the great thinkers of the past, including the founding fathers of this republic, who worshipped or at least believed in some form of a supreme creator.

I also question the wisdom of C&EN in prominently featuring biased reviews of a biased book on a controversial subject, such as creationism. All C&EN can expect is to antagonize either the convictions of the agnostic or being insensitive to the metaphysical beliefs of many members of the American Chemical Society.

Silve Kallmann
Research Director
Ledoux & Co., Teaneck, N.J.

For a balanced viewpoint

SIR: I have been meaning to write to you for some time on what I perceive to be an imbalance in the editorial treatment on the general atomic question; specifically, however, to the question of the "comprehensive test ban."

I refer to the June 4, 1984, issue of *Chemical & Engineering News*, which included your editorial and the letter from the two Soviet scientists. As a longtime member of the American Chemical Society, I decry this prejudice and feel that if it is going to be discussed, as indeed it should, it also should present a balanced viewpoint. We cannot remain free, unless we remain strong.

Paul W. Tucker
Phillips Petroleum, Bartlesville, Okla.

Corrections

- May 7, page 21: Badische also is a merchant supplier of caprolactam in the U.S.
- June 11, page 42: Exxon's chemical sales in 1983 were $7.69 billion, up 6% from 1982 and representing 8.1% of the company's total sales. Chemical operating profit was $376 million, up 700% from 1982, and 3.9% of the total. Identifiable chemical assets were $5.30 billion, or 8.4% of the corporate total. Chemical operating profit margin for 1983 was 4.9% and operating return on chemical assets was 7.1%.
- Aug. 6, page 25: The captions for the upper right and lower left micrographs in the box were transposed; the upper right micrograph is of fumed silica, the lower left micrograph is of titanium dioxide.

Drug Company Earnings Rose 13% in Second Quarter

But strength of U.S. dollar overseas plus increasing cost consciousness in health care market has continued to cut into profits

Hindered by the continuing strength of the U.S. dollar against other currencies and growing cost consciousness on the part of hospital purchasing agents, major U.S. pharmaceutical companies still raised their profits 13% overall in this year's second quarter over a year before.

A group of 17 diversified drug concerns with other business lines ranging from medical devices to specialty chemicals managed the earnings increase on a 6% rise in revenues, the same growth registered in the first quarter. The group's overall profit margin—net income as a percentage of sales—jumped to 10.9% from 10.2% in last year's second quarter.

Individual results varied widely, however, making it difficult to discern broad trends. At some companies, for instance, ethical drug sales rose strongly, whereas at others they slipped. The same variety was evident in the medical products sector, suggesting differing degrees of success on the part of producers struggling to cope with the changing realities of the health care market.

For the most part, though, earnings statements focused on the effects of the powerful dollar. Becton Dickinson, for example, rebounded from a $17.9 million loss in second-quarter 1983 to record a $15.4 million profit in this year's quarter. But the company points out that if exchange rates had remained unchanged from the previous year, sales would have been $4 million higher and net income 6 cents per share, or $1.3 million (8.4%), higher than they were. Pfizer, which reported a 7% revenue rise, says sales were up 10% on a local currency basis. A. H. Robins estimates that unfavorable foreign exchange rates reduced its sales $5 million and earnings $1.3 million in the second quarter. And Warner-Lambert, which earned $61.9 million in the quarter, says that the dollar's strength cut 4 cents per share, or $3.2 million (5.2%), from its net income.

Foreign exchange rates are particularly important to pharmaceutical companies, because typically a very large portion of their sales volume is transacted overseas. For example, 26% of Becton Dickinson's sales were

Profitability increased for most pharmaceutical firms

	SECOND-QUARTER 1984						FIRST-HALF 1984					
	Sales	Earnings[a]	Change from 1983		Profit margin[b]		Sales	Earnings[a]	Change from 1983		Profit margin[b]	
Company	($ millions)		Sales	Earnings	1984	1983	($ millions)		Sales	Earnings	1984	1983
Abbott Labs	$ 801.4	$100.4	11%	17%	12.5%	11.93%	$1522.5	$188.1	8%	17%	12.4%	11.5%
American Home Products	1198.5	158.3	4	11	13.2	12.4	2457.5	331.1	5	10	13.5	12.8
Avon Products	816.3	48.1	9	3	5.9	6.2	1541.9	77.7	6	3	5.0	5.2
Becton Dickinson	279.9	15.4	−1	def	5.5	def	565.6	29.0	−2	def	5.1	def
Bristol-Myers	1060.1	111.1	10	17	10.5	9.9	2116.0	221.1	10	18	10.4	9.7
Eli Lilly	723.9	114.0	−2	12	15.7	13.8	1618.7	260.7	3	9	16.1	15.1
Merck	891.3	131.4	8	7	14.7	15.0	1739.9	256.5	9	8	14.7	14.9
Pfizer	985.7	118.1	7	11	12.0	11.6	1905.5	245.8	4	13	12.9	11.9
Revlon	578.8	30.9	−1	3	5.3	5.1	1142.8	55.4	0	3	4.8	4.7
A. H. Robins	152.0	4.1	11	−70	2.7	9.9	308.3	20.0	13	−31	6.5	10.7
Schering-Plough	475.6	47.9	2	−5	10.1	10.8	962.1	101.2	3	−4	10.5	11.3
G. D. Searle	323.6	38.4	53	102	11.9	9.0	603.9	63.7	47	79	10.5	8.7
SmithKline Beckman	713.5	120.2	3	4	16.8	16.6	1432.3	250.7	4	4	17.5	17.6
Squibb	440.6	47.1	3	17	10.7	9.4	869.5	84.0	4	14	9.7	8.8
Sterling Drug	456.2	30.7	−2	7	6.7	6.2	903.2	60.9	−1	8	6.7	6.2
Upjohn	581.7	47.6	12	8	8.2	8.5	1144.7	112.7	14	26	9.8	8.9
Warner-Lambert	797.2	61.9	2	12	7.8	7.1	1574.6	116.1	2	14	7.4	6.6

a Excludes significant extraordinary and nonrecurring items. b After-tax income as a percentage of sales. def = deficit.

outside the U.S. in the second quarter. In 1983, 48% of Pfizer's sales came in its foreign business areas. For Robins, 1983 overseas sales accounted for 38% of all revenues.

As in the first quarter, G. D. Searle turned in the largest growth in earnings—up 102% from second-quarter 1983. And as before, Searle's performance derived its remarkable vitality from worldwide sales of its aspartame products, which accounted for 49% of the company's revenues in April, May, and June. The greatest decline in net earnings among the 17 firms fell to Robins, which was forced to pay out $15.3 million for litigation related to its Dalkon Shield contraceptive product. The net drop in profits was particularly galling to Robins in the second quarter, which featured a company sales record for the period and a 36% increase in operating earnings.

The second best earnings gains were achieved by Abbott Laboratories, Bristol-Myers, and Squibb, each with a 17% increase over second-quarter 1983. Abbott had record sales and earnings for the quarter, thanks to a 7% rise in pharmaceutical and nutritional products sales and a 10% increase in hospital and laboratory products sales.

Squibb reported a 1% increase in pharmaceutical sales, a slight gain in medical products sales, and a 15% jump in personal care sales by the company's Charles of the Ritz group. "The corporation's earnings progress for the year 1984 is tracking earlier expectations," chief executive Richard M. Furland says.

The most profitable firm in the group remained SmithKline Beckman, with a 16.8% profit margin. The company's net earnings increased only 4% during the quarter, but earnings per share jumped 7.9%. The disparity is accounted for by the firm's stock repurchase program, which reduced the total of outstanding shares of common stock about 3.3 million during the first half of 1984. The company also was helped by a sizable cut in its annual tax rate, thanks to recent tax legislation.

David Webber, New York

Higher costs in store for pigmented plastics

U.S. polyethylene processors can expect resin prices to decline during the 1980s, but prices for titanium dioxide and carbon black to compound with them will rise. The overall result will be increased costs of black- and white-pigmented polyethylene. These conclusions were aired last week at a press conference in New York City by two executives in the plastics industry.

Present worldwide polyethylene overcapacity, planned new capacity over the next four years, and needs of such oil- and gas-rich countries as Canada and Saudi Arabia to export will combine to depress U.S. prices, says Rolland G. Frakes, senior vice president at Novacor Chemicals, Calgary, Alta. These price drops in the U.S. and in potential export markets in the Pacific rim will cause plant shutdowns here, he adds, leading the U.S. to become a net polyethylene importer.

U.S. polyethylene supply to outpace demand

	1985		1988	
Billions of lb	Supply	Demand	Supply	Demand
Low-density polyethylene	6.7	4.8	6.2	4.7
Linear low-density polyethylene	3.5	2.8	4.0	4.2
High-density polyethylene*	6.8	5.7	7.4	6.7
TOTAL	**17.0**	**13.3**	**17.6**	**15.6**

* 2.5 billion to 3.0 billion lb of high-density polyethylene capacity could be switched to linear low-density polyethylene. **Source:** Novacor Chemicals

Moreover, Frakes says, linear low-density polyethylene (LLDPE) will slowly take over many U.S. high- and low-density polyethylene (HDPE and LDPE) markets, forcing shutdowns of some LDPE plants here and conversion of older HDPE plants to LLDPE. About 3.8 billion lb of new LLDPE capacity will start up over the next few years. Conversions of U.S. HDPE plants to LLDPE could grow from 4.4 billion lb in 1984 to 11 billion lb in 1988.

Taking up the subject of pigments used in polyethylene and other resins, Howard England, vice president for manufacturing at Ampacet Corp., Mt. Vernon, N.Y., says, "In our business, there is a relatively unpublicized problem involving two important raw materials, titanium dioxide and carbon black. They represent the largest volume of pigmented consumption in the plastics industry."

He says that current shortages and price rises for TiO_2 and carbon black came out of plant shutdowns for economic and environmental reasons in the recent recession. Ampacet makes resin concentrates. Suppliers of these most-used plastic pigments thus were caught short by the unexpected strength of economic recovery worldwide. As a result, prices for TiO_2 have risen 17% during 1984, and those for carbon black 32%. These increases more than offset resin price declines, England says, putting concentrates producers in a squeeze.

Moreover, this tight situation in price and supply for these pigments will persist for the next few years, England predicts. In the case of TiO_2, a plant takes four years to build, and no new capacity has been announced. The Ampacet executive estimates U.S. 1984 TiO_2 demand at 1.9 billion lb, compared with 1.75 billion lb of domestic effective capacity. Although 20% of U.S. TiO_2 needs are filled by imports, European economies also are growing, and competition for the white pigment will be sharp.

As for carbon black, England estimates 1984 U.S. demand at 2.95 billion lb and domestic effective capacity at 3.15 billion lb. He says that summer shutdowns in the rebounding auto industry have granted a respite from the tight supply situation. This is because 65% of U.S. carbon black production goes into tires, and 25% more into other rubber goods. However, producers again will be sold out this fall, he says.

Estimates from Columbian Chemicals Co., Akron, earlier this summer bear England out. Though production leaped 20% to 710 million lb in the first quarter of 1984 compared with the same period in 1983, Columbian analysts commented, inventories dwindled to 150 million lb, only a three-week supply. ☐

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CHEMICAL & ENGINEERING
NEWS

Chemical educators tackle issues at biennial conference
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Synthetic Fibers

Apparel imports hold back production growth

A Key Polymers Review *Page 11*

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CHEMICAL & ENGINEERING NEWS

SEPTEMBER 3, 1984

News of the Week

- **More than 11,000 attended the ACS meeting in Philadelphia. Page 4**
- **Lung disease suffered by cotton workers may be caused by boll endotoxins. Page 5**
- **New antiulcer drug moves toward regulatory approval. Page 5**
- **People and places caught by the camera at the ACS meeting. Page 6**
- **Harvard chemists report the first biomimetic synthesis of prostaglandins. Page 7**
- **Data on radioactivity released after Three Mile Island accident not complete enough to project health effects. Page 7**
- **Ray Irani is the new president of Occidental Petroleum. Page 8**
- **Sinking of French cargo ship carrying uranium hexafluoride highlights dangers of shipping nuclear materials in heavily traveled waters. Page 8**

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International Business

Shutdown of petrochemical maker Pétromont's ethylene plant at Varennes clouds Montreal petrochemicals development. **Page 15**

Government

Controversy over acid rain so far has focused on sulfur oxides but their control, even if legislated, may not be adequate if other sources contribute to environmental damage. **Page 18**

Environmental Protection Agency, NSF, and other federal agencies receive supplemental fiscal 1984 appropriations. **Page 20**

Education

Eighth Biennial Conference on Chemical Education finds teachers optimistic that science education reform is under way. **Page 22**

Science

Accidental melting of a diamond surface using a powerful laser beam led to formation of glasslike spherules. **Page 25**

Clues to some steps involved in converting normal genes to cancer-producing oncogenes discovered in U.S., British work. **Page 25**

ACS News

Brian A. Bernstein named treasurer of the American Chemical Society, succeeding Ellington M. Beavers. **Page 26**

Business

U.S. producers of synthetic fibers suffer from import competition, especially from Asia, but quota regulations may slow the decline. Page 11

Slumping Synthetic Fibers May Get Help from Import Limits

To go into effect in October, regulations would reduce imports of apparel, which are hurting U.S. production of polyester, nylon, acrylic fibers

Bruce F. Greek, C&EN Houston

Following a strong recovery, the synthetic fibers industry is not having a good year. Production of both polyester and acrylic fibers is forecast to decline in 1984. The major reason for this slump: increasing imports of products of these fibers, mainly in the form of apparel. Nylon fiber production will be up slightly, primarily because carpet is its major market and because imports of carpet that compete with U.S.-produced nylon carpet are small.

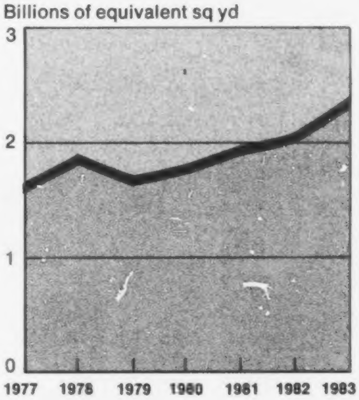
Some help is in sight, however. On Oct. 31, regulations are scheduled to go into effect that would limit imports of apparel to the U.S. These regulations, originally slated to take effect this week but delayed by Treasury Secretary Donald T. Regan late last month, are designed to reduce partly the fast rise in shipments of apparel to the U.S. Imported apparel has been cutting into sales of U.S.-produced apparel.

What the regulations say, in effect, is that countries whose apparel import quotas are filled no longer can ship finished or partially finished apparel to other countries whose quotas are not filled and where the apparel is finished and shipped into the U.S. under the unfilled quotas.

The new regulations likely won't be of much help to the synthetic fibers industry this year. And they probably will not reverse the rise in imports of apparel containing man-made fibers; they will merely slow their rate of growth, according to industry sources. Ways will be found to change quotas or to evade any kind of limits, especially under the pressure of the strong U.S. dollar.

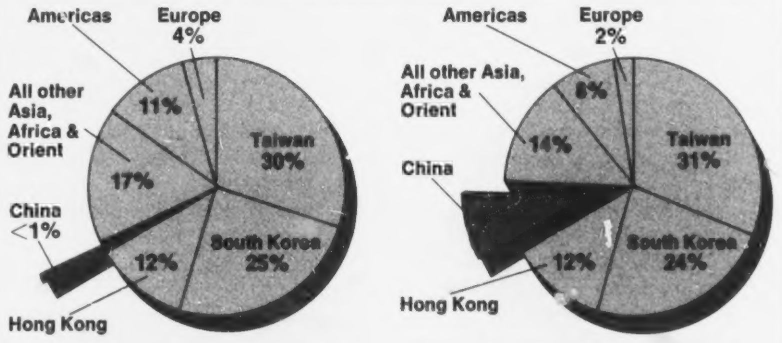
Key Polymers

Imports of man-made fiber apparel continue to rise



Source: Textile Organon

China gains in share of man-made fiber apparel imports, other Far Eastern countries hold share as total volume rises



Total 1977 = 1.07 billion sq yd

Total 1983 = 2.38 billion sq yd

Source: Textile Organon

The quantity of apparel imports in 1984 also is difficult to forecast. The gain, if the regulations are in effect for more than a quarter of the year, could be below the 13.4% increase of 1983 over 1982.

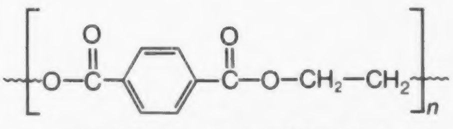
So far in 1984, imports of certain apparel items are up so much that, even with the new regulations, the total very likely will rise more than 10% again, possibly close to 15%, for the year. Even with stronger limitations on imports in future years, forecasts indicate that imports of apparel will continue to rise.

At the same time, declines in exports of U.S.-produced fibers, especially polyester, could continue. The net effect of lower fiber exports and higher apparel imports on U.S. synthetic fiber output could be the one predicted by many in the industry—that of a continuing decline.

For details of the current year's outlook for the three major synthetic fibers, please see the following pages.

Key Polymers

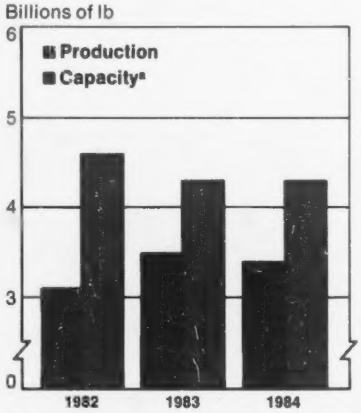
Polyester



Poly(ethylene terephthalate)

- ***Output down slightly***
- ***Capacity fall halted***
- ***Prices weaker***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Reaction of dimethyl terephthalate or terephthalic acid with ethylene glycol to make bis(2-hydroxyethyl)-terephthalate, which is polymerized catalytically to poly(ethylene terephthalate)

MAJOR END USES (U.S.)

Apparel 50%, home furnishings 20%, industrial 30%

FOREIGN TRADE

Exports—declining to 250 million to 300 million lb in 1984, imports—rising to more than 50 million lb

PRICES

150-denier textured filament 85 to 90 cents per lb; staple, 80 to 85 cents per lb; discounts vary

COMMERCIAL VALUE

$3 billion for production, 1984

Polyester fibers are facing the same major problem that other fibers are facing—the onslaught of imported apparel. The rise in imports of apparel containing polyester fibers and changes in fashion favoring other fibers, especially cotton, will combine to lower production of polyester fibers this year.

In 1984, production of polyester fibers will amount to about 3.4 billion lb, down about 100 million lb from 1983. This will be well below the record production in 1979 of 4.18 billion lb, which may not be matched for some years.

Capacity to make polyester fibers has been higher in the past. For the beginning of 1984, capacity totaled nearly 4.3 billion lb, off from the record by several hundred million pounds. Some increases in capacity are slated for 1984, but they will add less than 100 million lb to the total. Possible shutdowns could offset these gains.

Excluding the added capacity from any partial-year production, the operating rate for 1984 for polyester fibers plants will average nearly 80%. This will be off just slightly from the 1983 operating rate. But it may portend a slow decline in rates until some capacity is scrapped as obsolescent in the face of rising apparel imports.

Apparel and home furnishings account for nearly 75% of polyester consumption in the U.S. These diverse uses are those being hit by imported products and by fashion changes.

Some analysts estimate that this year imports of apparel containing polyester fibers will be up at least a third over those in 1983. Such a gain, and it could be higher according to other views, lies behind the difficult times being experienced in the textile industry. Demand growth for all kinds of apparel now averages 1 to 3% a year, meaning that imported finished apparel heavily cuts into demand for domestically produced apparel.

Fashion changes also are having a big impact on polyester demand. Consumption of materials with higher cotton contents in blends with polyester or all-cotton fabrics is rising.

All-cotton garments also are reported by some analysts as beginning to cut into demand for polyester fibers. Both domestic and foreign apparel made of cotton seem to be selling well now. Apparently imported all-cotton apparel is selling competitively, partly because China has had two years of above average cotton crops and other, smaller cotton producers in the world also have had good crops.

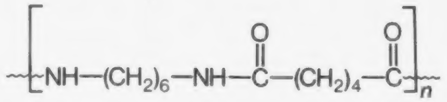
In the past, imported apparel made in part or entirely of polyester fibers has had lesser effect on U.S. fiber production. This was because fiber was exported to be returned as finished apparel. Now several other countries have polyester fiber operations that are competing with U.S. fiber exports. The net result of lower exports is an additional, although lower, pressure on U.S. polyester fiber production. As a result of this competition, U.S. exports of polyester fibers in 1984 are estimated at no more than 300 million lb, and probably will be below this level.

Home furnishings markets for polyester fibers are not yet strongly affected by imports. Imports of sheets, tickings, and other bedding components are rising fast, but from a small base. Polyester meets strong performance competition from nylon in carpet uses and goes mainly into lower-cost carpet.

Industrial uses of polyester fibers are rising with the economic recovery, especially in such areas as tire cord, plastic- and rubber-coated fabrics, and hose. Tire cord is recovering on a volume basis, but is not back to historical levels when few radial tires were used and all new cars had a conventional-size spare tire.

Polyester, as the largest volume synthetic fiber, could be the indicator for the future. Its future growth will slow or possibly decline, owing to foreign competition in finished apparel. If output is to turn up again, costs all along the line will have to be reduced.

Key Polymers



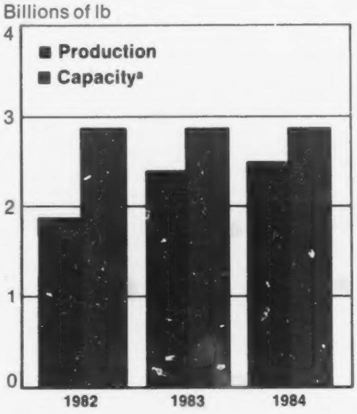
$$\sim\left[\text{NH}-(\text{CH}_2)_6-\text{NH}-\overset{\text{O}}{\overset{\|}{\text{C}}}-(\text{CH}_2)_4-\overset{\text{O}}{\overset{\|}{\text{C}}}\right]_n\sim$$

Nylon 66

Nylon

- ***Production to rise***
- ***Capacity holding***
- ***Prices improved***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Nylon 66—adipic acid and hexamethylenediamine reacted to form hexamethylene diammonium adipate, which is polymerized by removal of water; nylon 6—caprolactam polymerized by addition and subsequent removal of water

MAJOR END USES (U.S.)

Home furnishings 60%; apparel 20%

FOREIGN TRADE

Exports—to rise to about 125 million lb this year, imports—to increase to about 50 million lb

PRICES

Carpet staple $1.10 to $1.25 per lb; apparel grades $1.50 to $3.00; discounting continuing

COMMERCIAL VALUE

$3 billion for production, 1984

Nylon's success in 1984 will depend on the construction business—more specifically, on carpet use. There is probably enough nylon fiber produced, either ready to go into carpet or in manufactured carpet, to meet demand for the rest of the year. A surge in carpet demand during the last quarter probably would not help nylon fiber production this year, but it could set the stage for a fast start in 1985.

Since housing starts have been relatively strong, but so far not at record-breaking levels for much of 1984, nylon fiber demand has risen. This probably will result in an increase in nylon fiber production of 5% or a bit less for all of 1984 to about 2.5 billion lb. The gain this year will be in the 100 million lb range, a shadow of the gain in 1983 when production rose almost 500 million lb during the economic recovery. Production in 1982 of 1.93 billion lb was the lowest since 1971.

Nylon fiber production capacity is holding at about 2.9 billion lb a year. A small portion of this capacity apparently can be used to make other fibers. Neglecting the very small swing capacity and taking 1984 production at 2.5 billion lb, the operating rate for this year once again will run above 85%, a level reached in the late 1970s.

No new capacity is expected to be built anytime soon. Now that the economic recovery is well under way, gains in production are expected to be small. Additional capacity will be obtained from the usual debottlenecking methods and through replacement of lines of old machinery. The amount of additional capacity to be added is forecast to be small for the next few years. This situation will prevail until capacity is pushed very hard.

Prospects now are for continued small gains in production next year unless a major downturn in the economy occurs during the second half. Housing use of nylon carpet may not gain much next year, but prospects are good for the commercial or contract carpet business to follow its usual lagging cycle of feeling the effects of a recession last and recovering last.

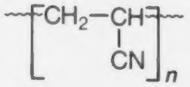
With home furnishings taking more than 60% of nylon fiber production, this use gets most of the attention by forecasters. Home furnishings should really be termed carpet because all other uses of nylon fibers in home furnishings total 5% or less. Hence, with more than half of nylon fiber use going to carpets, and a major share of this in home carpets, analysts are watching closely all the factors that influence housing construction and sales.

Of the noncarpet uses of nylon fibers, about half is apparel and half industrial uses. Each of these categories further breaks down into many small markets. None of these are changing enough to have significant impact on total nylon demand this year, but some are improving as a result of fashion changes and the recovery.

Most of the apparel items proffer steady demand for nylon fibers, even during recession times. No new developments have occurred to change demand in such items as underwear, nightwear, robes, socks, or sweaters. Hosiery has received a slight boost from fashion as a result of a shift toward more patterns and colors.

Industrial uses of nylon fibers are being boosted as expected by the recovery. Tire demand, especially for truck and off-the-road tires, has been strong and is expected to remain so because of the expanded road building programs. This will continue even with a slowdown in the economy. Tire cord accounts for roughly 50% of the industrial demand for nylon fibers and probably will change little over the next few years.

On balance, nylon, in its main use as carpet, accounts for most of the market, so the fiber's capture potential is small. Therefore, the outlook for nylon will be that of slow, steady growth when averaged over good and bad economic times.



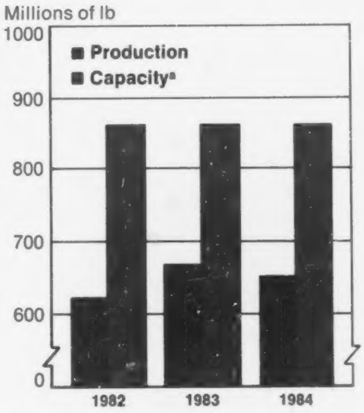
$$-\!\!\left[CH_2-\underset{\displaystyle CN}{CH}\right]_n\!\!-$$

Polyacrylonitrile

Acrylic

- ***Production off a bit***
- ***Capacity on hold***
- ***Prices steady***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Polymerization of acrylonitrile, a product of the reaction of ammonia and propylene

MAJOR END USES (U.S.)

Apparel 65%, home furnishings 30%, industrial 5%

FOREIGN TRADE

Exports—to decline to under 150 million lb in 1984, imports—to rise to about 20 million lb

PRICES

3-denier staple for apparel 90 cents to $1.10 per lb; discounting significant

COMMERCIAL VALUE

$600 million for production, 1984

After a good recovery in 1983, acrylic fiber production will decline slightly in 1984. The major cause of this year's slump in production is the same as that for all of the synthetic fibers' production growth problems—imports of products of these fibers, mainly in the form of apparel. For acrylic fibers, rising imports of apparel and a decline in exports of the fiber itself combine to have a greater effect than for the other important synthetic fibers.

In 1984, production of acrylic fibers probably will be down 3% from its 1983 level to about 650 million lb. Most industry analysts expect this to be the top end of what will be produced this year. However, their forecasts of production range from 630 million to 670 million lb.

Capacity to make acrylic fibers generally is holding level. Minor debottlenecking is taking place but won't add significantly to capacity. Estimates of capacity range from 810 million to 870 million lb a year, depending on the fiber denier.

If capacity is about 860 million lb and if production reaches 650 million lb, then the average plant operating rate in 1984 will be more than 75%. This operating rate will be slightly below the average for the chemical industry this year. In addition, it will be well below the recent historical high for acrylic fibers of 91% in 1980 when production was more than 780 million lb from about the same capacity.

The operating rate in 1983 was a couple of percentage points higher at nearly 78%. This could be the best operating rate of the next few years, unless some major technical development or fashion change aids acrylic fibers, according to some industry observers. This low operating rate and the prospect of slowing demand could continue to put pressure on acrylic fiber prices.

Imports of apparel made of acrylic fibers are reducing domestic use and production of this fiber. Imported women's sweaters this year could account for half of U.S. sales, possibly as much as two thirds. Imported men's sweaters lag women's in their share of sales, making up one third to one half of the total U.S. market. Thus, imports may account for half of U.S. retail sweater sales in 1984. Sweaters currently account for about 15% of acrylic fiber use.

Fashion, too, is influencing demand for acrylic fibers in sweaters. Cotton is staging a comeback in sweaters as well as in many other apparel items, many of which don't contain acrylic fibers.

Gains in use of acrylic fibers in several areas of active or sportswear offset some of the losses in demand in sweaters caused by imports. Socks, long an important use of acrylic fibers, continue to be strong this year with good gains except for the lowest priced, so-called "tube" socks, which increasingly are being made of cotton. Demand for active wear is in even better shape because of the growing interest in sports and physical fitness.

Some of acrylic fibers' old standbys, however, aren't doing so well and may decline fairly rapidly in their share of the fiber use. Craft yarns, for example, are weak now for reasons that are unclear except for an assumption that today fewer people knit at home. Acrylic fiber blankets, long considered aesthetically pleasing substitutes for more expensive wool blankets, are in a slump, partly because of market capture by lower-cost polyester fiber blankets. Carpet use continues to decline because of competition from polyester and nylon fibers.

Clearly, what acrylic fibers need is some fashion or technical development to make them the preferred fiber, regardless of cost, in present or new uses. These fibers also need some relief from imports of apparel. As a result, the small decline in production in 1984 could be repeated next year and each year thereafter for some time unless acrylic fibers get a new market to spur their use.

Adhesive monomer capacity tightens Page 10

Candidates in ACS fall election: Their views and backgrounds Page 42

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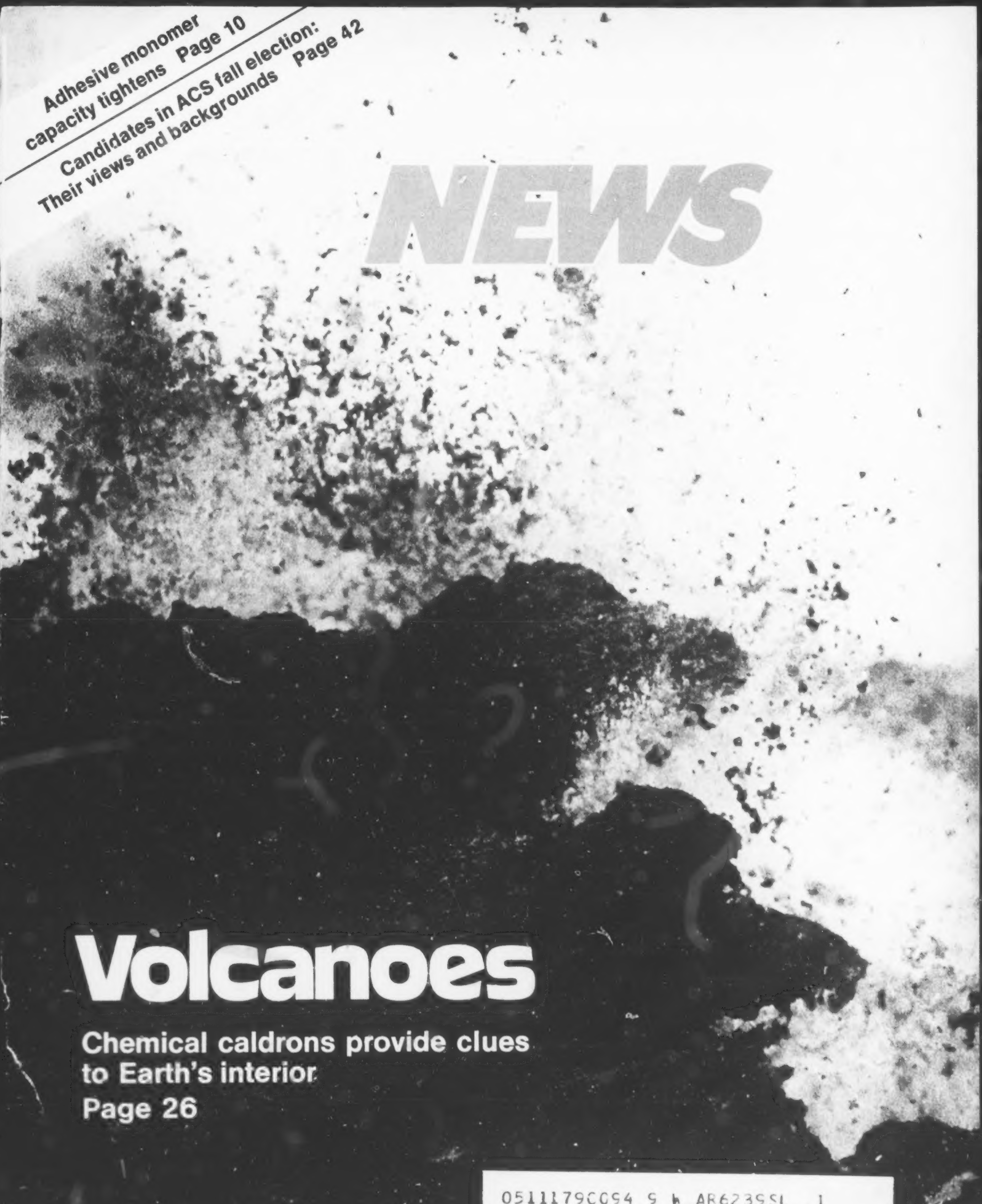

Volcanoes

Chemical caldrons provide clues to Earth's interior

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CHEMICAL & ENGINEERING NEWS

SEPTEMBER 24, 1984

News of the Week

- **Du Pont chairman calls for firming of government regulations on industrial uses of biotechnology at opening of company's life sciences research complex. Page 6**
- **InterNorth will acquire Texaco's Chemplex unit. Page 7**
- **FDA okays the use of Monsanto's acrylonitrile/styrene bottle for nonalcoholic beverages. Page 7**
- **Proposed West European academy of scientists would provide forum for deliberating science-related topics. Page 7**
- **Union Carbide and McGraw-Edison set up joint venture to remove PCBs from transformers. Page 8**
- **New weed killer acts through photosensitivity. Page 8**

Cover: Lava fountains from eruption of Mauna Loa volcano, Hawaii, March 26, 1984. Photo by USGS's James D. Griggs

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Demand for organic intermediates phenol and vinyl acetate nears capacity, which may lead consumers to rely on imports. **Page 10**

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West European chemical producers are enjoying higher earnings, in part because of continued strength of the U.S. dollar. **Page 14**

Government

OTA study suggests slowing down pace of Superfund cleanup, waste-end tax for funding, but Congress isn't interested. **Page 16**

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Potential new markets for lignin in adhesives, foams, and plastics result from advanced techniques to study its structure. **Page 19**

South Korean fertilizer industry must innovate technologically if it is to regain competitiveness in world markets. **Page 21**

Chemical sensor based on a chemical modifying the properties of an optical sensing element developed at Sandia labs. **Page 22**

Study of formation of carbon-carbon bonds in methanol in presence of metal acetylides adds to research in isosynthesis. **Page 23**

ACS Election

Candidates for ACS president-elect, directors for Region III and Region VI, and director-at-large present platforms. **Page 42**

Special Report

Volcanoes—from the violent erupters like Krakatoa to the gentler effervescers like Kilauea—are intriguing studies for geochemists. Page 26

Phenol, Vinyl Acetate Face Tightening Supply

As demand increases, plants for producing these organic intermediates are operating at near capacity this year; users may have to turn to imports

Bruce F. Greek, C&EN Houston

A continuing upturn in demand for two important organic intermediates—phenol and vinyl acetate—for making adhesives and coatings has brought plants making these two chemicals to the limit of their capacity. With these plants operating at top rate, if demand continues to rise, more capacity may have to be added—possibly through debottlenecking and restarting some shutdown production units. Otherwise, consumers may have to rely more on imports.

With the increased demand for both phenol and vinyl acetate plus full utilization of capacity, substantial price increases also might have been expected. But although prices have increased some, the increases have been only modest and certainly not large enough to encourage producers to build additional capacity to make these materials.

Prices haven't increased any more, largely because consumers have the upper hand in negotiations as a result of stiff competition from other materials. Consumers are bargaining with producers on prices, emphasizing that producers' raw material costs apparently have declined. Benzene, ethylene, and propylene have list prices below year-ago levels. Energy prices also have remained steady or declined, so processing costs probably are not much higher if at all. Process improvements should have offset increases in other components of production cost.

Key Chemicals

But despite increasing demand, competition in end uses remains strong for phenol and vinyl acetate. For example, acrylic materials for making water-based paints remain very competitive with vinyl acetate even with considerable improvement in the vinyl acetate polymers offered in the paint field. This gives consumers of the two products considerable clout in price negotiations.

Because producers must keep the cost of the monomers as low as possible (too low for reinvestment size profitability, according to producers), demand for these materials remains strong enough to hold plant operating rates at a level where modest profits can be made.

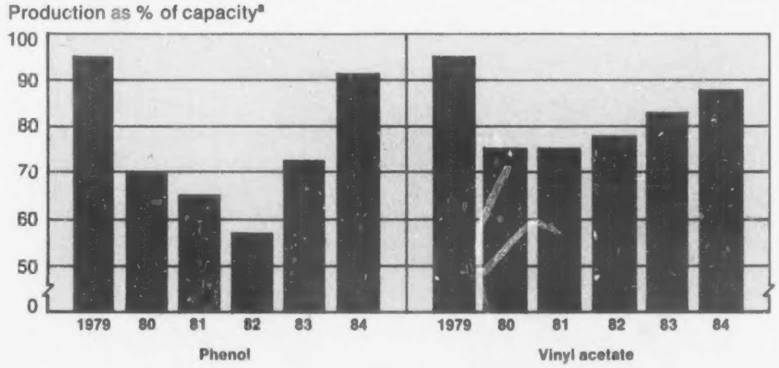
Additional capacity clearly seems to be needed, however, if production of these materials is to expand. Forecasts for growth in demand for phenol and vinyl acetate fall in line with forecasts for that of most major volume organic chemicals now—3 to 5% per year until 1990. At an average rate of 4% annual growth, roughly a one-third increase in production would be expected. Neither phenol nor vinyl acetate capacity now exists to permit that much additional production.

For new capacity to be added, at least two years' lead time is needed. Producers might get by without a large-scale plant for two years through debottlenecking, a slowdown in demand if there's another recession, and lower exports.

The most likely scenario for future capacity for phenol and vinyl acetate, according to various industry sources, will be a combination of some new capacity (mostly from debottlenecking), some restarting of shut-down capacity (possibly shifted to a new location), lower exports, and higher imports. Only if selling prices for these materials rise unexpectedly well will a new large-scale plant be built in the U.S. by the end of the 1980s.

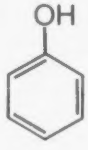
For details of the near-term outlook for these two intermediates, please see the following pages.

Production pushes capacity for intermediates near limits



a First-quarter nameplate capacity. **Sources:** International Trade Commission, industry and C&EN estimates

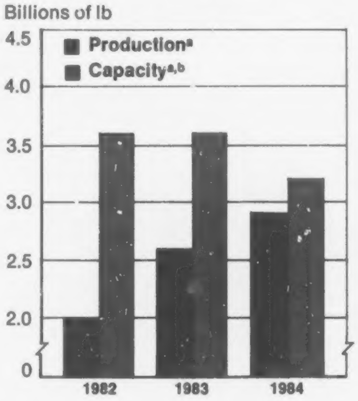
Key Chemicals



Phenol

- ***Demand higher***
- ***Capacity to rise***
- ***Prices up***

PRODUCTION/CAPACITY



a Synthetic only. b First quarter.

HOW MADE

Peroxidation of cumene (isopropyl benzene) and cleavage to phenol and acetone

MAJOR DERIVATIVES (U.S.)

Resins (mostly with formaldehyde as comonomer) 40%, bisphenol A 20%

MAJOR END USES (U.S.)

Adhesives 60%, plastics 20%

FOREIGN TRADE

Exports—to hold at about 100 million lb in 1984, imports—small and holding around 25 million lb

PRICES

List prices 36 to 39 cents per lb, discounts still significant

COMMERCIAL VALUE

$1 billion for production, 1984

This year phenol will join that small, but growing, group of organic chemicals whose excess capacity is about used up. Production of synthetic phenol in 1984 could exceed 3 billion lb, surpassing the 2.95 billion lb record set in 1979.

Since 1979, considerable changes have occurred for phenol. Nameplate capacity has continued to rise and exceeded 4 billion lb in 1981. Then following a severe decline in production during the recession to about 2 billion lb in 1982, capacity also dropped.

Monsanto is the latest to leave the phenol business, dropping 500 million lb from the 1983 capacity list. Minor debottlenecking offset a part of this shutdown capacity, but the current total, at about 3.2 billion lb, will be strained if 3 billion lb of phenol are produced in 1984.

Even if production falls a little short of the 1979 high this year, the average operating rate for plants on stream as the year began will be 90% for all of 1984. But some help is coming. By the end of this quarter, Georgia-Pacific will be putting some 157 million lb of capacity on stream in a plant that has been shut down for several years.

Additional debottlenecking is going on as well, which will add a bit to phenol capacity and help the snug supply. These small expansions could total between 100 million and 200 million lb when added up by the end of 1985.

List prices for phenol have risen so far in 1984 and some discounts have been taken off. This has helped to raise the previous low returns on sales of phenol and its derivatives. (Merchant sales account for about half of the production of phenol, although for some producers, sales are very small.) Considering current and expected returns on sales, producers still are unlikely to build new plants. A producer would require a large captive use to justify a plant, with any phenol for sale as incremental production.

Capacity additions by debottlenecking may be all that will be needed for several years. If 1984 production reaches 3 billion lb, it will be just 3.4% above the previous high. This tiny growth means that for the past five years production of phenol languished—hardly an incentive to build new capacity. Therefore, small capacity additions likely will be enough to get through 1985 when demand again might slow as the economy cools.

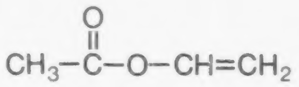
Exports, of course, are a potential outlet for additional product made in the U.S. Currently, exports of phenol probably will amount to about 100 million lb, about the same as last year. Exports could be reduced to meet internal demand, but exporters have some investment in special handling equipment for phenol on which they would like to keep earning some return. New foreign plants also could cut into exports.

Adhesives—particularly those made with formaldehyde—for the housing market account for a major share of the consumption of phenol. This market depends heavily on housing demand. But, even if housing demand slows next year and, in turn, demand falls for plywood made with phenol-based adhesives, enough demand remains in other phenol uses for it still to have a good year. Inventory changes in plywood have some influence on adhesive demand, which could cause temporary swings in phenol demand as plywood inventories are liquidated and then rebuilt quickly.

Other applications for phenol are much smaller, and many also are connected with housing and with auto production. They also are partly responsible for pushing phenol production to capacity limits this year, but they, too, would decline if the economy slows. After many poor years, the many uses are making a very good year for phenol.

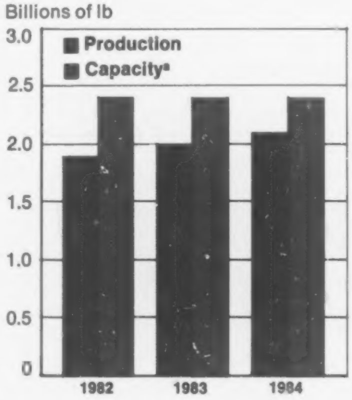
Key Chemicals

Vinyl Acetate


$CH_3-\overset{\overset{O}{\|}}{C}-O-CH=CH_2$

- ***Demand rising***
- ***Capacity tightening***
- ***Prices firming***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Vapor-phase reaction of ethylene, acetic acid, and oxygen

MAJOR DERIVATIVES (U.S.)

Polymers 55%, polyvinyl alcohol 20%, copolymers 15%

MAJOR END USES (U.S.)

Adhesives 35%, paints 20%, paper and textile coatings 20%

FOREIGN TRADE

Exports—may decline slightly in 1984, but will exceed 500 million lb; imports—negligible

PRICES

List prices 34 to 39 cents per lb, discounts lessening

COMMERCIAL VALUE

$750 million for production, 1984

Vinyl acetate production in 1984 will increase modestly from last year. Strength in housing and in auto production, along with the general improvement in the economy, are behind this production growth.

However, vinyl acetate production growth will lag behind that for many other major-volume organic chemicals for two reasons. Probably the most important reason to producers is that demand held better during the recession than for many other chemicals. So its recovery has not been as dramatic. The second reason and the most important to customers is that not a great deal of excess capacity exists for vinyl acetate.

Vinyl acetate production this year likely will total at least 2.1 billion lb and may even reach practical effective capacity of 2.2 billion lb. That would mean that plants would run near effective capacity, or in the range of 87 to 91% of total nameplate capacity in place at the beginning of 1984.

Some small capacity additions are on the way. They probably will add about 100 million lb to the total when completed next year. As debottlenecking additions, they also will come on stream in small increments, making estimates of capacity difficult to pin down. The capacity expansions are partially dependent on additional capacity to make acetic acid, supply of which also has become relatively tight this year.

These additions will no more than meet additional demand for vinyl acetate expected in 1985, and possibly not even that. Any additional demand above that which can be produced by the existing and added capacity will be met by diversion of vinyl acetate from export markets. In 1984, the combination of the strong dollar and improving demand in the U.S. apparently will keep exports down from earlier levels.

Besides exports of the monomer, derivative exports also increase the total quantity of vinyl acetate exports. These polymers' exports individually are not large, but have added more than 100 million lb to the amount of vinyl acetate that eventually will be exported.

In the U.S., most of the major uses of vinyl acetate are increasing in volume at about the same rate under the push of the improved economy. Paints of various kinds will require about 4% more vinyl acetate as emulsions made with copolymers than last year. Interior paints still account for the majority of trade sale paints made of vinyl acetate copolymer emulsions, but exterior paints using vinyl acetate are gaining a bigger share as improvements develop in paint adhesion through use of various comonomers.

Adhesives compete strongly with paints for the title of being the largest end-use market of vinyl acetate. (Polyvinyl alcohol and other derivatives also eventually end up in adhesives.) Demand for adhesives containing vinyl acetate varies to some degree with the economy because a big share goes into packaging adhesives for boxboard and seam materials. With the strong economy, demand for vinyl acetate in this adhesives use is up 4 to 5% so far this year. Other kinds of adhesives based on vinyl acetate are smaller in volume, but together add up to another very sizable use of this monomer.

Other end uses such as paper coatings, textile sizes, polyvinyl butyral for auto safety glass laminates, and the many copolymer resins all are adding to vinyl acetate demand. And no matter what happens to the economy, demand for relatively recession-resistant vinyl acetate likely will remain strong into next year.

Even with this strong current demand, and with prospects for less decline during recessions, no large capacity additions will be available for quite some time. Thus, tight supply could remain a problem for vinyl acetate.

OCTOBER

CHEMICAL & ENGINEERING

NEWS

FINAL PROGRAM
1984 International Chemical Congress
of Pacific Basin Societies—Honolulu
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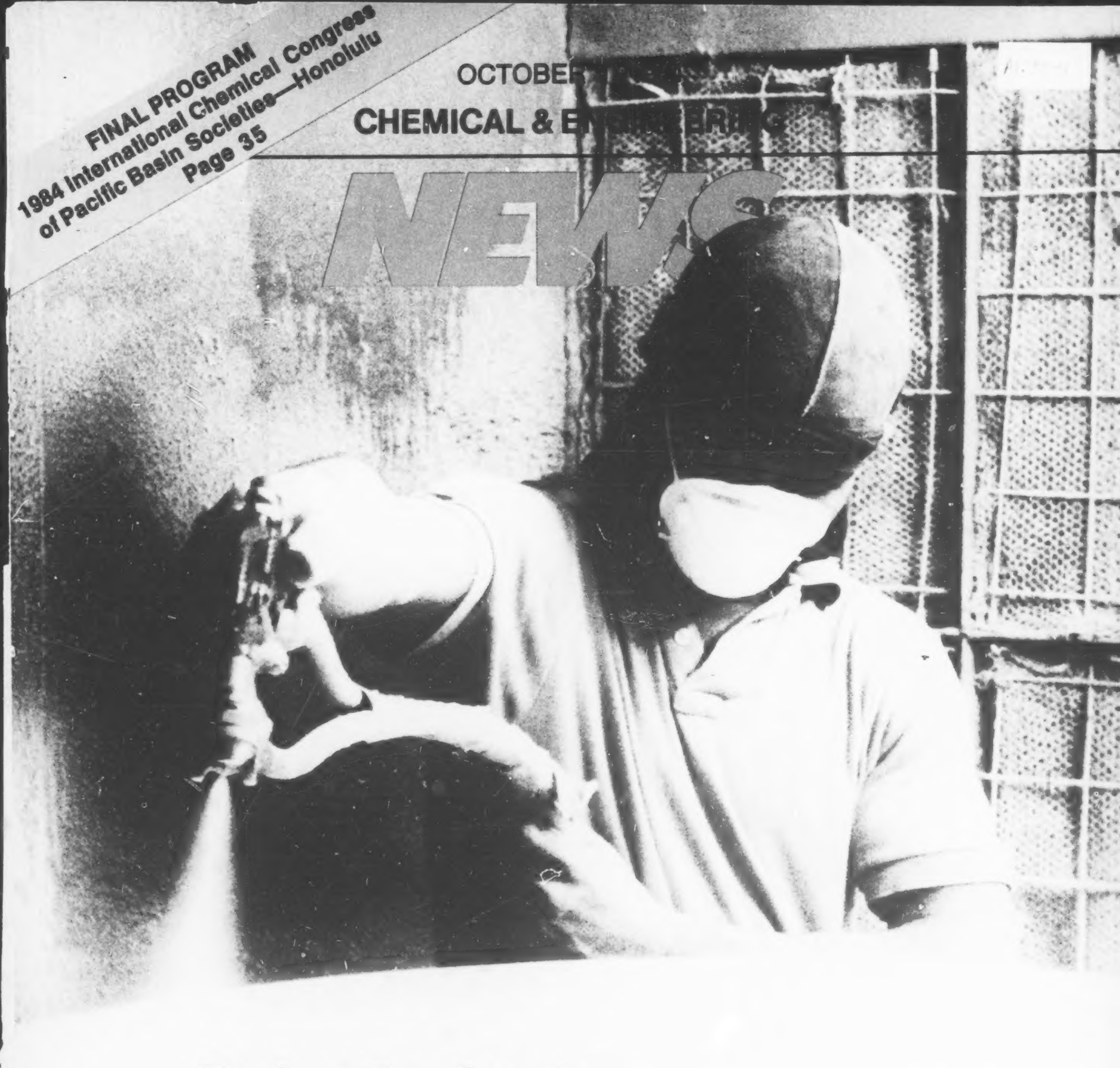

Paint Industry Heads for Record Year

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CHEMICAL & ENGINEERING
NEWS
OCTOBER 1, 1984

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News of the Week

- **Judge approves settlement of agent orange suit between Vietnam veterans and seven chemical firms.** Page 4
- **GAO study of conflicting NAS reports on diet and health says that both followed good scientific practices.** Page 5
- **Signal UOP will expand its Des Plaines research center, physically and in areas of research.** Page 5
- **Gene from bacterium found in raw sewage produces enzyme that digests lignin.** Page 5
- **Erosion is depleting the world's topsoil at a rate of 25.4 billion tons a year, study finds.** Page 6
- **Antiapartheid terrorists bomb Union Carbide's Tarrytown technical center.** Page 6

Cover: Workman at Woodlee Furniture Corp., Paterson, N.J., sprays table with high-solids, low-fume unsaturated polyester finish made by Mobay

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Employment in plastics, paint, and agricultural chemicals areas of the chemical industry suffered most in the recession; revenues of biotechnology firms increased 92% in second quarter. **Page 10**

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"Endorphins: New Waves in Brain Chemistry" summarizes study of the neurotransmitters and their function in the body. **Page 25**

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Final Program

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Spred
Gel-Flo

Product Report

The paint and coatings industry is enjoying record-setting growth in shipment volume that is continuing recovery begun last year. **Page 51**

Recession's Harm to Chemical Employment Detailed by New Data

Hardest hit sectors were plastics, ag chemicals, and paint; some such as drugs weren't affected, according to Labor Department figures

William J. Storck, C&EN New York

The recession is long past and chemical production is once again on the rise, with an accompanying increase in hiring of chemical workers. But how bad the recession actually was for employment in the chemical industry has only recently come to light through just-published data from the Department of Labor.

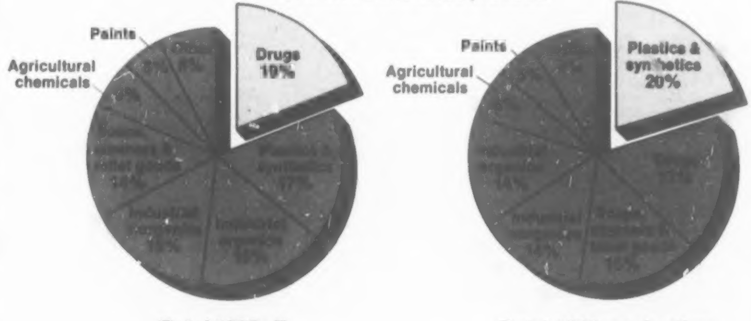
For instance, in spite of the recession's ending in late 1982 for the general economy and in the second quarter of 1983 for the chemical industry, employment in the chemical industry in 1983 continued lower than it was during the year before. And, although chemical employment began to turn up at about the same time as the chemical economy, the lagging nature of employment—plus the efficiencies put in place by chemical companies during the recession—tended to slow employment growth all during 1983.

Thus, last year, employees for chemicals and allied products totaled about 1.05 million, down 3% from 1982. This follows an equal reduction in 1982 from the year before. Between 1979, the last good year for the chemical industry, and 1983, employment in the chemicals and allied products sector dropped 6%.

Total employment in all U.S. manufacturing industries fared even worse. According to the Labor Department, jobs in all manufacturing fell 2% in 1983 from the previous year to 18.5 million, but 1982 was off 7% from 1981. And the number of employees last year was 12% below the 1979 level.

Drugs employs the most chemical industry workers, but plastics has most production workers

Chemicals and allied products



Total 1983 all employees = 1,046,800

Total 1983 production workers = 580.800

Source: Department of Labor

Within the chemical industry itself, production workers fared worse than other employees during the recession. Whereas total chemical employment fell 6% between 1979 and 1983, the number of production jobs dropped 8% to 580,800. Between 1982 and 1983, their drop was the same as that for total chemical employment at 3%, but between 1981 and 1982, production employment fell 5%, compared with the 3% drop for total chemical jobs.

Not all segments of the chemical industry were affected equally by the recession. For two categories—drugs; and soaps, cleaners, and toilet goods—employment actually increased between 1979 and 1983. Drug employment by 1983 totaled 199,700, up 4% from 1979. In the past two years, drug industry employment has remained almost unchanged. For soaps, employment rose 3% in the period to 143,000, despite drops of 1% in each of the past two years.

On the other side of the coin, during the 1979–83 period of economic crunch, employment for plastics, agricultural chemicals, and paint companies was especially hard hit. Employment in the plastics and synthetics sector fell 17% to 176,200. It took big drops in both 1982 and 1983, falling 6% and 5%, respectively. For agricultural chemicals, employment fell 14% between 1979 and 1983 to 60,600 workers. All of this and more came during 1982 and 1983 while the government's payment-in-kind (PIK) crop set-aside program was in place. In each of those years, employment in agricultural chemicals dropped 7%. And paint companies also were pinched badly, with employment falling 13% to 59,700 in 1983 from its 1979 level.

The Labor statistics show that women chemical employment fared

Industrial inorganics suffered greatest drop in employment

Thousands	1983	1982	1979	% change 1982–83	% change 1981–82	% change 1979–83
ALL EMPLOYEES						
Chemicals & allied products	1046.8	1075.1	1109.3	−3%	−3%	−6%
Industrial inorganics	155.1	160.2	162.1	−4	−1	−4
Plastics & synthetics	176.2	184.7	212.2	−5	−6	−17
Drugs	199.7	198.8	192.5	0	0	4
Soaps, cleaners & toilet goods	143.0	143.9	139.5	−1	−1	3
Paints	59.7	59.9	68.6	0	−6	−13
Industrial organics	162.9	170.8	171.4	−5	−4	−5
Agricultural chemicals	60.6	65.3	70.2	−7	−7	−14
Miscellaneous	89.5	91.0	93.0	−2	−4	−4
PRODUCTION WORKERS						
Chemicals & allied products	580.8	598.6	633.3	−3%	−5%	−8%
Industrial inorganics	79.1	85.[illegible]	88.0	−8	−3	−10
Plastics & synthetics	114.3	119.3	143.6	−4	−8	−20
Drugs	97.5	98.2	95.5	−1	−1	2
Soaps, cleaners & toilet goods	89.7	90.2	84.3	−1	−2	6
Paints	29.2	28.9	35.5	1	−8	−18
Industrial organics	83.6	85.9	88.8	−3	−4	−6
Agricultural chemicals	36.7	39.6	45.0	−7	−10	−18
Miscellaneous	50.8	50.9	52.5	0	−6	−3
WOMEN EMPLOYEES						
Chemicals & allied products	273.0	279.2	270.7	−2%	−2%	1%
Industrial inorganics	25.7	25.2	23.4	2	3	10
Plastics & synthetics	36.5	40.4	44.6	−10	−6	−18
Drugs	86.1	85.7	79.1	0	0	9
Soaps, cleaners & toilet goods	58.5	58.4	55.9	0	−3	5
Paints	11.4	11.6	12.7	−2	−6	−10
Industrial organics	25.6	27.4	25.2	−7	−1	2
Agricultural chemicals	9.0	10.0	10.0	−10	−6	−10
Miscellaneous	20.1	20.5	19.9	−2	−4	1

better during the 1979–83 period than did chemical industry employment as a whole and better than overall women employment in all manufacturing industries. Whereas total employment in the chemicals and allied products industry fell 6%, the number of women employees rose 1% to 273,000. And in spite of dropping in the past two years, the 2% decline each year for women employees was less than the 3% decline for all chemicals and allied products employees.

The 1% rise in the number of women employed in the chemical industry contrasts with the 8% drop for women employed in all manufacturing. And, although female employment in all manufacturing remained steady in 1982 and 1983, it fell 6% between 1981 and 1982.

According to the Labor Department figures, women comprised about 26% of the workforce in the chemicals and allied products industry last year, up from 24% in 1979 and 23% in 1977. But although this percentage is rising, it still lags considerably the corresponding percentage in all manufacturing industries, where 32% of all employees last year were women.

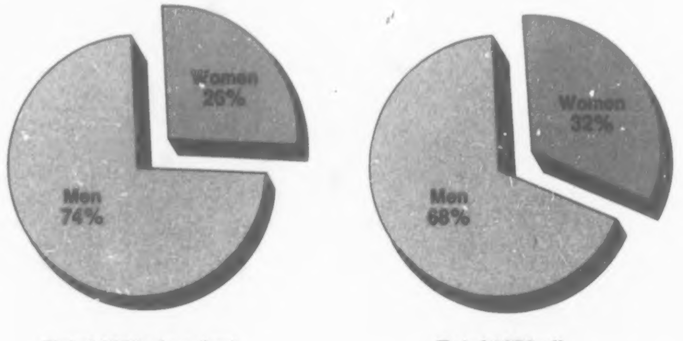
An interesting note derived from the Labor Department figures: By far the largest employer of women in the chemical industry are drug companies, whose 86,000 female employees made up 32% of last year's drug company workforce.

The drugs sector, in fact, employed more chemical workers in 1983 than any other industry sector, with 19% of total chemicals and allied products employees. However, of total production workers, it ranked second, with 17%. Employment breakdown for the plastics and synthetics sector was reversed, ranking second in total employees with 17%, but first in production workers with 20%.

In terms of all employees, industrial organics ranked third with 16% of total chemical industry employees. This was followed by industrial inorganics with 15%, and soaps, cleaners, and toilet goods with 14%. The agricultural chemicals sector employed 6%, and paints 5%, of total employees. Miscellaneous chemical producers employed the remaining 8%.

As before, however, these industry sectors didn't follow the same rankings in terms of percentage of production workers, which tend to show the relative labor intensity of the different chemical lines. For example, the soaps, cleaners, and toilet goods sector employed 15% of total chemical production workers, and industrial inorganics and industrial organics each employed 14%. □

Chemical industry lags all manufacturing in percentage of women employees



Total 1983 chemical industry = 1,046,800

Total 1983 all manufacturing = 18,497,000

Source: Department of Labor

Biotechnology revenues surged in second quarter

The financial statements filed by biotechnology-based companies continue to look less and less like those of development-stage firms. True, the majority of companies are still reporting net losses or, at best, small profits. But undeniable signs of commercial status proliferate in the increasing share of total revenues made up of operating proceeds, especially those from product sales. These indications are more evidence that the many companies using new biotechnology in the fields of health care, agriculture, and chemicals—as well as those which supply them with laboratory reagents and devices—are rapidly growing up.

A group of 15 companies representing a cross section of the biotechnology-based industry recorded a composite 92% increase in total revenues in the second quarter of 1984. At the same time, only six members of the group reported net income. But companies are plowing the bulk of their revenues back into research and development; at this point profit margins are more tokens of appeasement to institutional investors than actual measures of a company's health.

What most biotechnology-based companies are aiming for now is increasing the importance of sales dollars in the revenue mix—assuming they have some products on the market in the first place. Genex, for instance, which reported a 352% second-quarter jump in total revenues—the largest in the 15-company group—points out that product sales accounted for 69% of all revenues during the first half of 1984, compared with less than 1% in the same period in 1983. For Monoclonal Antibodies, whose total revenues for the April-through-June period rose 215%, product sales also played the decisive role—rising to $715,160 from $81,877 in the same period the year before. That was thanks to the introduction of an ovulation prediction kit in May and the fifth of a line of pregnancy test kits in June.

Other firms also boosted their product sales. Centocor, which reported a 69% rise in revenues, also managed a $103,549 profit. "Profitability increased as a result of expanded product sales," comments company president Hubert J. P. Schoemaker. Over the first half, Molecular Genetics, which last year began selling its first product, a monoclonal treatment for calf scours, had product sales of $827,428, or 17% of total revenues. And Ribi ImmunoChem Research recorded a 51% jump in revenues during the second quarter, the result of increasing sales for the company's veterinary antitumor agent.

Not all the best-known biotechnology-based companies have noticeable product sales, however. Biogen, for instance, managed healthy 39% revenue growth without any products. Of its total, 73% came from research and development contract fees, the remainder from interest income. Similarly, Amgen, with a 278% leap in second-quarter revenues, made 47% of that on R&D fees and 50% on interest, leaving just 3% for sales and royalty revenues.

Genentech also derived most of its revenues from contract research. The company, which also had undisclosed revenues on royalties from Eli Lilly for the genetically engineered human insulin Genentech developed and from some product sales for clinical use, is still trying to gain clearance from the Food & Drug Administration for its first major product, human growth hormone. At one time, the company had expected FDA approval before the end of 1983. Now, nearly a year later, a September meeting with FDA resulted in another request for more data.

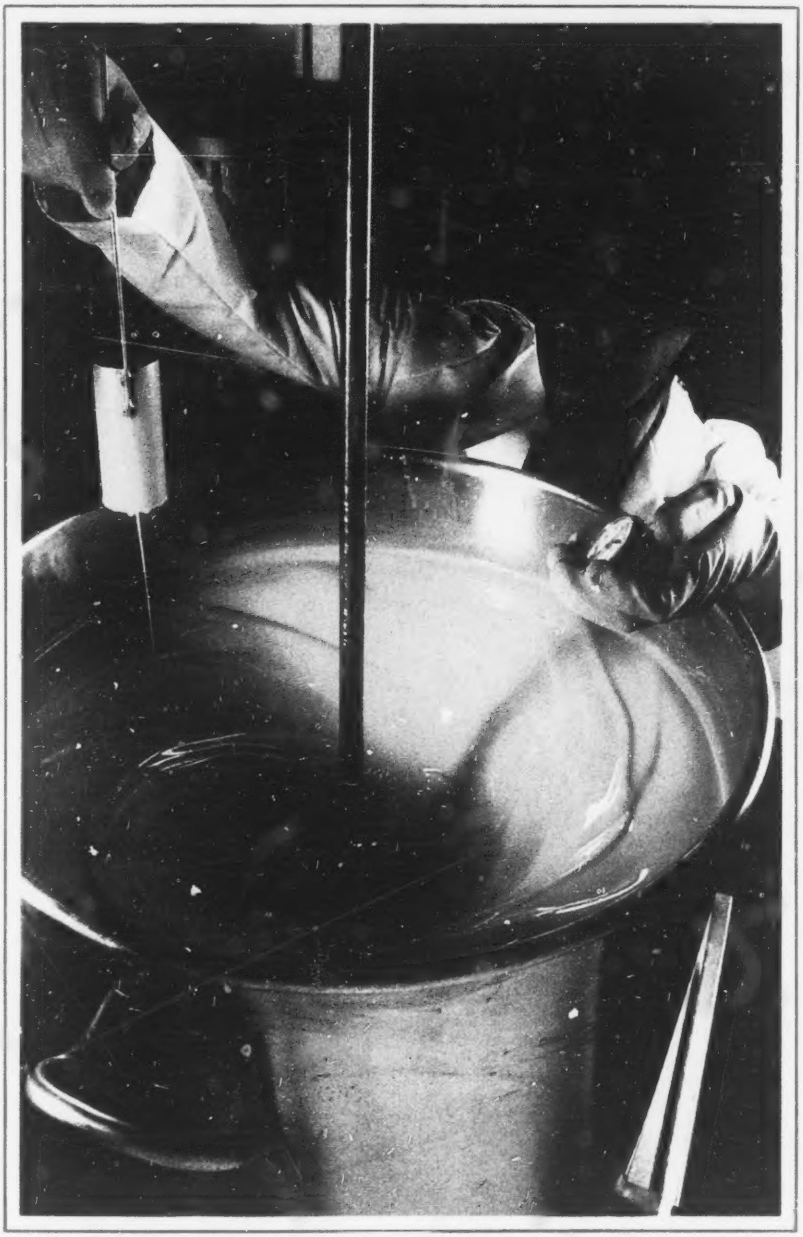
David Webber, New York

Revenues increased 92% in the second quarter

	SECOND-QUARTER 1984[a]						FIRST-HALF 1984[b]					
	Revenues[c]	Earnings[d]	Change from 1983		Profit margin[e]		Revenues[c]	Earnings[d]	Change from 1983		Profit margin[e]	
	($ Millions)		Revenues	Earnings	1984	1983	($ Millions)		Revenues	Earnings	1984	1983
Advanced Genetic Sciences	$ 0.0	$−1.9	−92%	def	def	def	$0.1	$−3.5	−92%	def	def	def
Amgen	1.9	−2.1	278	def	def	def	na	na	na	na	na	na
Applied Biosystems	5.9	1.1	125	220%	16.3%	12.8%	10.9	2.0	148	354%	18.6%	10.2%
BioTechnica International	0.4	−1.1	119	def	def	def	0.8	−2.1	252	def	def	def
Biogen	7.8	−4.5	39	def	def	def	13.8	−8.2	43	def	def	def
California Biotechnology	2.1	0.0	67	63	1.9	1.9	4.1	0.1	93	24	3.1	4.8
Centocor	2.7	0.1	69	def	3.8	def	5.2	0.1	81	def	2.1	def
Cetus	13.7	0.2	77	def	1.7	def	25.7	0.3	57	def	1.3	def
Collaborative Research	3.3	−0.8	234	def	def	def	na	na	na	na	na	na
Damon Biotech	1.5	−0.6	162	def	def	def	2.9	−1.2	156	def	def	def
Genentech	17.3	0.6	57	88	3.6	3.0	32.6	1.0	57	80	3.1	2.7
Genex	8.3	−2.0	352	def	def	def	14.2	−3.6	318	def	def	def
Molecular Genetics	2.2	0.0	19	−92	0.9	13.6	4.8	−0.0	60	def	def	4.3
Monoclonal Antibodies	1.0	−0.6	215	def	def	def	1.8	−1.6	225	def	def	def
Ribi ImmunoChem	0.2	−0.1	51	def	def	def	0.5	−0.2	52	def	def	def

a For three-month period ending closest to June 30. b For six-month period ending closest to June 30. c Includes sales, contract research, royalty, and interest revenues. d Excludes extraordinary credits. e After-tax income as a percentage of revenues. na = not available. def = deficit.

Coatings Industry Heading for Record Year



Technician at Du Pont's Troy Laboratory checks viscosity of test batch of paint

David Webber, C&EN New York

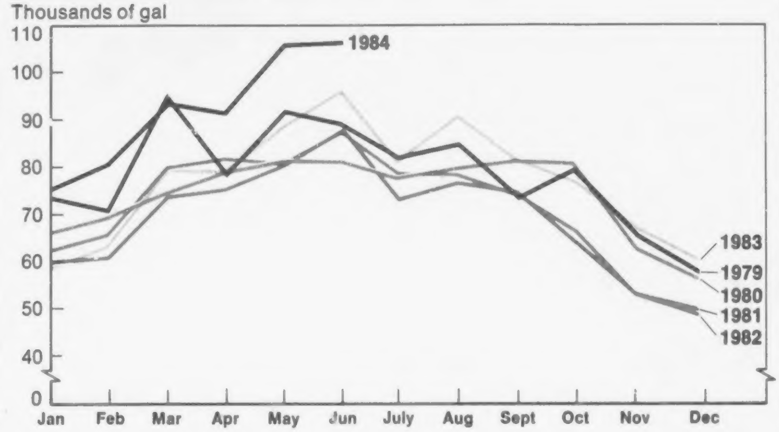
Everyone knows the paint industry is a mature one. So when a largely sedate business—one in which executives talk wistfully about keeping up with the gross national product—acts out of character, positively sprightly, in fact, it makes for a memorable year.

That's the case in the paint industry now. Having last year made up most of the ground lost since the industry peaked in 1979, shipment volume for the total paint and coatings industry continued to surge during the first half of 1984. At midyear, the industry appeared headed for a record performance.

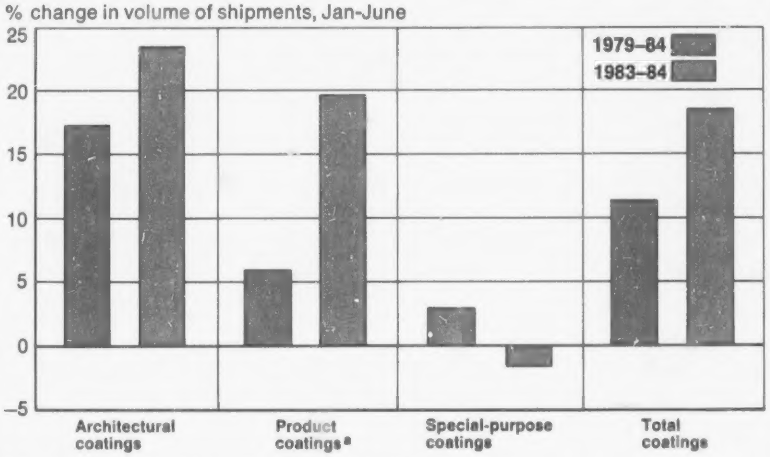
Lifted by the wave of economic expansion in the U.S., coatings shipment volume rose to 523 million gal in the January-to-June period, according to statistics compiled by the Commerce Department's Bureau of the Census, 12.3% above the 466 million gal recorded during the equivalent time period in 1983. That's good growth following a year in which gallonage increased 12.0% from the previous, albeit recession, year.

Even more pleasant to coatings producers and their suppliers, the six-month shipment total was 11% higher than that for the same span in 1979, which so far remains the top year ever in terms of volume. Much can happen in the second half of 1984 to alter this year's record-setting pace, of course, but the second quarter is always the peak three-month period for the seasonal coatings industry, and this year's April, May, and June shipments were well above those for 1979. So even though the economy began to slow down during the third quarter—the Federal Reserve's flash estimate for GNP growth was just 3.6%—it would take an unlikely disruption in the

1984 coatings shipments were exceeding record 1979 pace at midyear . . .



. . . but not all sectors improved equally in first-half 1984 compared to earlier years



[a] Original equipment manufacturers. **Source:** Department of Commerce

marketplace to keep business this year from fulfilling its promise.

There is even humor in the coatings industry this year. Du Pont, in search of a new "paint farm" on which to test the weathering characteristics of its high-performance finishes, recently purchased a nudist camp in Florida. The nudists have been ousted, local environmentalists are worried about the fate of the pine trees on the property (Du Pont says they are safe), and jokes about the acquisition are sure to abound at this year's Federation of Societies for Coatings Technology Paint Show. To head them off, perhaps, a company spokesman notes that, although brochures for the camp have been in evidence at company headquarters in Wilmington, Del., no Du Pont employee actually visited the place while campers were in attendance. He notes, on the other hand, that the purchase should prove the inaccuracy of a recent publication's characterization of the firm as "stodgy."

This rosy picture of the industry needs to be qualified somewhat, of course. First of all, there has long been a good deal of dissatisfaction with the Census Bureau statistics. Reacting to criticism that its method, which uses a sample group of companies and multiplier to come up with volume and value totals, was exaggerating the market, the Census Bureau last year revised its sample in an attempt to reflect actual business activity more accurately.

The effort, though applauded for its intent, has not met with wholesale approval. Analysts of business volume believe the totals are still inflated. At SRI International, for instance, Eleanor M. Connolly estimates that the 12.3% first-half jump reported by the Census Bureau is higher than the real increase. A number of others, from both within and without the coatings industry, agree, guessing that growth in the January-to-June period probably fell instead somewhere in the range of 9 to 11%.

This does not, however, invalidate the trend shown by the government statistics. For one thing, those dissatisfied with the figures say that the totals are probably equally exaggerated in previous years, despite the revisions. And Juliette Benedicto, of the National Paint & Coatings Association's management information office, points out that there is a close trendline correlation between the government's figures and NPCA's internal survey of coatings volume. That survey consists of confidential reports from a group of companies a little more than one fifth the size of the Census Bureau sample. A plotting of percentage changes in the NPCA survey, she says, very closely tracks a similar rendition of the Census statistics.

The other qualification of the industry's overall glossy look is that this year's surge has not swept up all sectors of the coatings business equally. It has been a truly good year in general for makers of architectural coatings—the sector composed mainly of interior and exterior house paints, stains, and varnishes. Volume at midyear was up 24% over the same point in 1983 and up 17% over that for 1979, according to Census Bureau statistics. Also doing very well have been product coatings sold to original equipment manufacturers (OEM). Shipments in this sector, which includes coatings for the automotive, wood furniture and fixtures, metal container, and other industries, were nearly 20% higher than in first-half

1983 and 6.0% higher than in first-half 1979.

Left behind by this wave of success is the special-purpose coatings sector. Because of spotty recovery by some of its major end-use markets, which include automotive refinishing, high-performance maintenance coatings, traffic paint, and others, shipments in the special-purpose sector actually declined 1.5% over the first six months of 1984. They were up just 2.9% from the same period in 1979.

Much of the reason for this pattern of growth and contraction can be seen in the performance of the major markets that consume the bulk of the U.S. paint and coatings industry's products. Residential construction, for instance, is a major influence on sales of house paint, varnish, and stain, of course, as well as on consumption of OEM coatings for factory-finished wood. The growth of the architectural coatings sector over the first half is reflected in the prime barometer, housing starts, which ran at a high annual pace until dropping sharply in August.

Domestic automobile production, obviously the chief influence on sales of OEM automotive finishes, also increased briskly during the first quarter, although it has been tapering off since then, according to the Federal Rese~~rve Board's~~ industrial production index. Another large economic trend that has helped the coatings industry this year has been continued high defense spending by the Reagan Administration—a boon to makers of aircraft and marine finishes as well as to marketers of urethane coating systems, which are being applied to Army vehicles to protect them from chemical weapons. Still another economic boost has come from increasing emphasis on repairing the nation's infrastructure, resulting in higher sales of traffic paints and bridge coatings.

Paint and coatings statistics revision

Readers comparing shipments statistics for the 1979–82 period published here with statistics for the same period published last year (C&EN, Oct. 3, 1983, page 25) will notice some large differences. Since January 1983, the Department of Commerce's statistics on coatings shipments have been based on reports from a different group of companies than that used before. Statistics used in graphs, tables, and text of this article for the period before January 1983 have been revised by the Commerce Department for comparability.

This year's healthy performance so far follows a year of strong recovery from the recession low reached in 1982. Last year, shipments of architectural coatings jumped to 463 million gal, up about 12% from the 1982 total. The value of those shipments rose to $3.84 billion, almost 24% higher than in the previous year. In the product coatings-OEM sector, shipment volume increased to 331 million gal, up 15% from the year before, and value rose to $3.0 billion, 16% higher than in 1982. And in the special-purpose coatings sector, which had been steadier during the recession, shipment volume grew 6.1% compared to 1982, and value shot up 21%.

This kind of overall growth is not expected to continue unabated. The essential maturity of the coatings industry and its close dependence on markets that track the GNP and population growth will keep expansion in check. Business Trend Analysts, Commack, N.Y., for instance, projects compounded annual volume growth for the period between 1982 and 1992 of 1.5% for architectural coatings, 2.5% for product coatings-OEM, and 3.1% for special-purpose coatings. For the composite coatings industry, the forecasting firm predicts average annual growth of 7.0% in value over that same span, but factoring out anticipated inflation, real growth will amount to about 2.0%.

Although expected to grow the most slowly, the architectural coatings sector remains the largest of the three broad coatings markets. In 1983, house paints and the like accounted for some 50% of total coatings shipments of 923 million gal and 45% of a sales total of $8.6 billion. The architectural coatings sector's link to the health of the housing market has brought it success so far this year, and companies say revenues were up well over the first half. But there are negative aspects in both short- and long-term respects that are expected to restrain growth in the future.

Of most concern this year are interest rates, which have been rising most of 1984 as a function of the financial community's fear of the huge federal budget deficit. Mortgage rates have risen in turn, pricing portions of the population out of the housing market. Last week's

Coatings fall into three major end-use groups

Architectural coatings
Exterior house paints
Interior house paints
Undercoaters, primers, and sealers
Varnishes
Stains

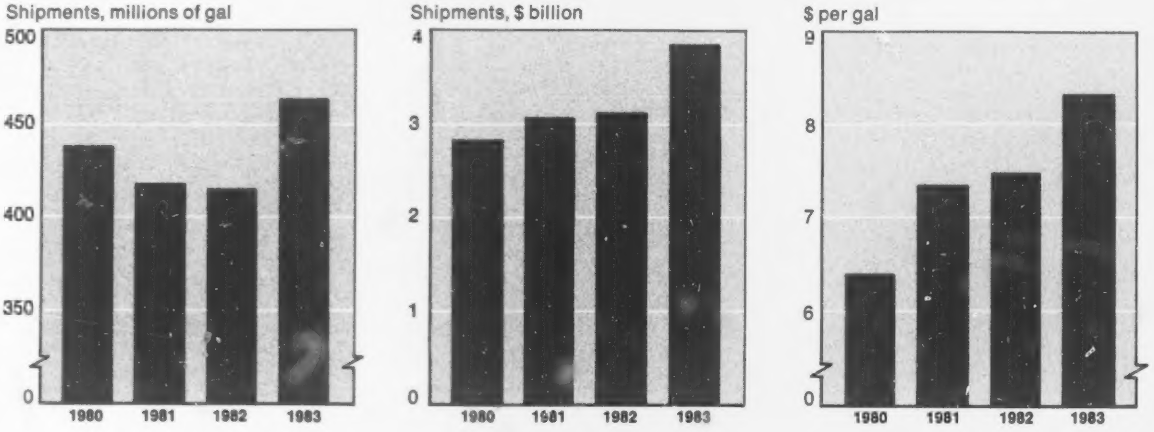
Product coatings-OEM[a]
Wood furniture and fixtures
Automotive
Metal containers
Machinery and equipment
Factory-finished wood
Metal furniture and fixtures
Sheet, strip, and coil
Transportation (nonautomotive)
Appliances
Electrical insulation
Marine
Film, paper, and foil
Pipe
Toys and sporting goods
Miscellaneous consumer and industrial products

Special-purpose coatings
Automotive and machinery refinishing
High-performance maintenance
Traffic paint
Roof
Bridge
Aerosol
Swimming pool
Arts and crafts
Metallic
Multicolored

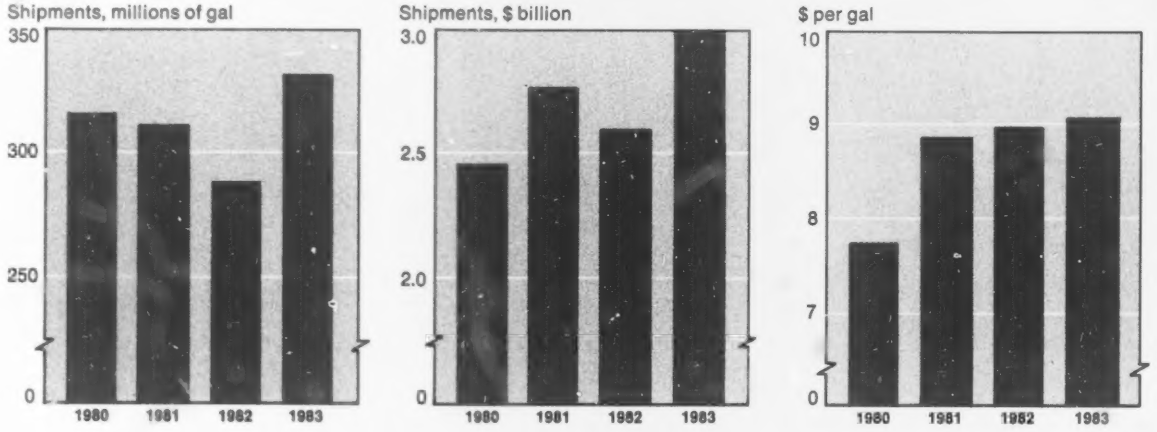
a Original equipment manufacturers. Source: SRI International

Shipments reversed downward trend last year

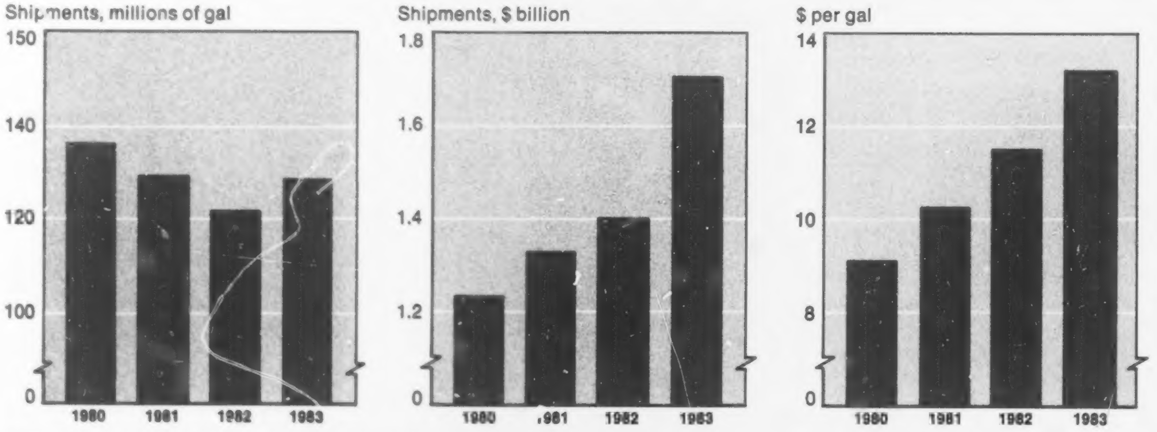
Architectural coatings



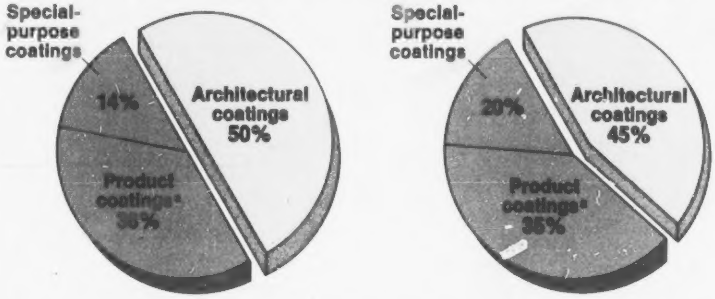
Product coatings[a]



Special-purpose coatings



a Original equipment manufacturers. **Source:** Department of Commerce



Architectural coatings were half of shipments in 1983

Total shipments = 923 million gal **Total value of shipments = $8.6 billion**

a Original equipment manufacturers. **Source:** Department of Commerce

0.25% drop in the prime rate is seen as an encouraging sign, but economists are not yet ready to say that the danger of further rate increases is over.

Manufacturers Hanover Trust, for instance, recently argued that "the sharp increases in interest rates that occurred during the first half of this year have again placed home ownership beyond the reach of an ever-growing segment of the general public." The bank's economic bulletin points out that sales of new single-family homes this summer were well below the peak reached last December, leaving builders with more than a half-year's supply of unsold new homes, one of the highest inventory levels in almost two years.

Marine Midland Bank's chief economist, Albert DePrince, likewise notes that though overall housing activity remains strong, single-family home sales are slowing in response to interest rate pressures.

This short-term trend is actually an instance of a longer-term tendency in home construction: the steadily increasing vitality of multiunit residential construction compared to that of traditional single-family dwellings. In 1975, for example, single-unit homes accounted for 77% of all housing starts, compared to just 18% for residential structures

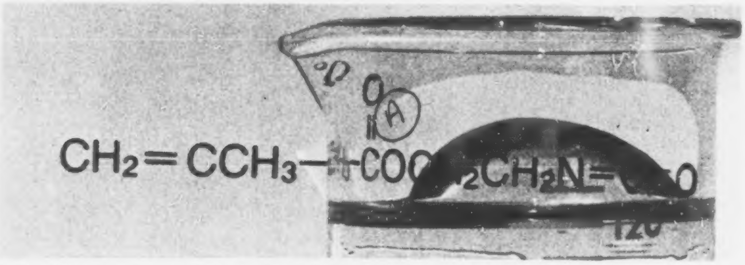
Paint industry's regulatory concerns: seeking consistency

For the U.S. coatings industry, the most significant government action of recent years is still the Environmental Protection Agency's action to reduce emissions of volatile organic compounds. That requirement, which has a 1988 deadline, has hastened, among other things, the automotive industry's shift from lacquer to higher-solids enamel coatings. The industry has other regulatory and legislative concerns, however, which, even if not likely to have so immediate and widespread an impact as the volatile organics ruling has had, are considered key because they could set precedents that industry members see as onerous. What particularly worries the industry is the spread of regulations and ordinances on the state and local levels. Often, industry executives say, these rules are more stringent than the federal version that addresses the same area. And a proliferation of local rulings means a loss of regulatory consistency, a development that can add to cost and confusion for companies manufacturing a coating product in one state and shipping it for use in another, producers say.

The National Paint & Coatings Association (NPCA), the industry's chief trade group, is concentrating its attention now on state and local oversight. "There's nothing we see on the federal regulatory frontier that's particularly threatening," says Bruce Hamill, the association's general counsel. According to him, the key issues now are:

- Hazard communication rule. NPCA is currently engaged in a lawsuit defending the Occupational Safety & Health Administration's position in a case, United Steelworkers of America vs. Auchter, now pending in the U.S. Court of Appeals 3rd Circuit. NPCA is working to defend the idea that the OSHA rule pre-empts local right-to-know requirements.
- Superfund reauthorization. In a case that does involve federal legislation, NPCA is making "a priority use of its resources" to seek what it calls "fair and equitable apportionment" of the cost of cleanup, an issue it considers crucial for the association's many small company members.
- State right-to-know laws. NPCA is seeking consistency among such requirements. "It's not that the individual states' requirements tend to be so burdensome," Hamill says. "It's the diversity that is problematic."
- Leakage from underground storage tanks. "A big, hot issue that's coming along," Hamill says. Currently under consideration in California are requirements for the monitoring of underground storage tanks, a feature of many coatings production facilities, through wells or liners.
- Transportation regulations. In New York City, NPCA is negotiating with municipal authorities for some easing of local regulations governing transportation of a number of coatings raw materials. The ordinances are stricter than federal regulations regarding truck safety specifications and driver certification, according to Hamill. "It's not an industrywide problem," Hamill says. "It's the precedent that bothers us."
- Chronic hazard labeling regulations. Of current concern to NPCA are state efforts to require hazard warnings on containers of art materials. "We see it as setting a pattern for all sorts of labeling regulations," Hamill explains.
- Solvent abuse. "Paint sniffing" by adolescents has led to laws in Texas that require a ban on sales of spray paints to minors. NPCA, which says there has been a "noticeable increase" of such abuse in recent years, is helping put together a public-service group called SAFE (Solvent Abuse Foundation for Education) that will seek to dissuade adolescents.

Clearly...



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with five units or more. Since then, the single-unit percentage has steadily shrunk, while the multiunit percentage has steadily swelled. By 1982, only 62% of all privately owned new housing starts were single-family dwellings; 30% of the starts were structures with five units or more.

This trend is generally considered bad for paint producers, because multiunit residences such as apartment buildings and condominiums are more frequently constructed of brick or stone than are single-family units. That means less paintable surface.

But the amount of paintable surface has been shrinking for more than one reason. For one thing, the average size of new houses has been declining. Reflecting this, according to Business Trend Analysts, the cost of paint per $1000 of construction price in single-family housing dropped from $6.51 in 1969 to $6.10 in 1982, an average annual decrease of 0.5%. Similarly, in multifamily housing, the cost per $1000 of construction price fell from $7.19 in 1969 to $6.78 in 1982, an annual decline of 0.6%.

In addition, paint marketers must continue to fight their ongoing war with wallpaper and paneling for the interior market and with aluminum and vinyl siding for the exterior protection market. Architectural coatings producers are somewhat optimistic on this score; they believe that the pace of penetration of siding has slowed.

"Siding has not had in the last several years as much of an impact. Now it is more of a battle between aluminum and vinyl siding," remarks John S. Dumble, president of the Glidden coatings and resins division of SCM Corp., one of the leading house paint producers along with Sherwin-Williams, PPG Industries, DeSoto, Standard Brands Paint Co., and Clorox. "The effect has been a modest one. Both aluminum and vinyl siding sales represent paintable surfaces that are lost to us, but it has stabilized as far as the architectural market is concerned. Now it is more a shift from aluminum to vinyl than a shift from painting to siding."

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Product Report

Titanium dioxide: supply tight, prices rising

Between 1973 and 1983, U.S. production of titanium dioxide, the largest-volume pigment used by the coatings industry, remained essentially unchanged. That, the multiple recessions of the past decade, and regulatory pressures were enough to convince a half-dozen producers to quit the business. The last new production facility, built by Du Pont, was completed in 1981, and TiO_2 had all the look of a commodity chemical product well settled into its maturity. As recently as last year, producers were anticipating very little growth in consumption for the rest of the 1980s.

The picture looks somewhat different now. Domestic TiO_2 output, coming off a 14% drop in recession-year 1982, jumped 15% in 1983, and, according to some estimates, could rise another 5.6% this year. The result is tight supply, rumors of allocation, and a hasty scramble to raise some plant capacities by debottlenecking.

"The industry was not prepared for the tremendous surge in demand as the economy recovered worldwide, particularly in those areas that are strong consumption points for titanium dioxide," says Howard England, vice president for manufacturing at Ampacet Corp.

Those areas—paint (which accounts for about half of TiO_2 consumption), paper, and plastics—have done well in the current expansion. Paint shipments jumped 12% last year over the disastrous 1982 performance and, at mid-1984, were running more than 12% above 1983's first-half pace, according to Commerce Department statistics.

In response, domestic TiO_2 producers Du Pont, SCM, American Cyanamid, and Kerr-McGee reportedly have been operating their facilities near or at the limit of their effective capacities. Ampacet's England forecasts U.S. demand of some 880,000 tons this year. He puts effective capacity at 800,000 tons. Net imports will make up the difference.

Looking beyond the U.S., he sees the same tightness of supply now and expects it to persist. According to his calculations, total global demand will amount to 2.45 million tons in 1984. With a total world capacity of just 2.60 million tons, plants will have to operate at 94% of their capacity to satisfy the marketplace's appetite. In 1986, he says, the situation will be little different. Global capacity will have grown to 2.68 million tons, but demand will have risen to 2.52 million tons, keeping the capacity utilization requirement at 94%.

There are a number of debottlenecking projects under way, but, as England points out, no new plants have been announced. "It takes approximately four years from date of announcement to startup to bring a plant on stream," he says. "So this tight supply situation will continue not for several weeks but possibly for several years."

In the meantime, SCM last month spent $110 million to buy LaPorte Industries' TiO_2 business. The acquisition, which includes a plant in the U.K. and one in Australia, adds 110,000 tons a year to SCM's capacity, which was expanded last year by the purchase of Gulf & Western's 35,000-ton Ashtabula, Ohio, unit.

Taking the long view, Alan Ferguson of SRI International sees the potential for tightness in TiO_2-containing minerals supply as well. There was ample supply in 1982, he points out, but besides the shutdown of five mines over the past five years, additional closings are expected before 1987. As a result, additional mineral capacity will be needed, he says. Whether the need is met will depend on whether two expansions of existing mines and one new mine each in Australia, South Africa, and India come on stream as planned between now and 1987.

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ness Trend Analysts' recent study of the paint and coatings industry, expenditures by residential property owners for paint rose 2.8% in 1982, whereas spending on siding dropped 5.7%. But the consulting firm considers this an anomaly; over the next decade, it forecasts a decline in total volume of exterior paints because of long-term growth by aluminum and polyvinyl chloride siding.

Glidden's Dumble also points out that the trends in housing starts,

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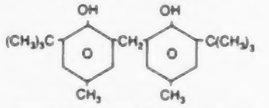

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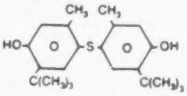

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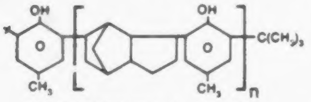

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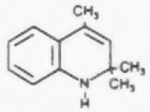

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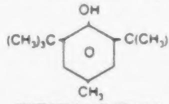

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both long and short term, do not reflect the greatest portion of the business for house paint—the residential resale market.

"Someone who buys an existing house or is getting ready to sell a house tends to be a very heavy user of paint," he says, "and the resale market is significantly larger than what you have with the new housing market." But that business segment also, he notes, is tied to interest rate fluctuations.

If interest rates do constrain housing activity in the coming months, architectural coatings producers will look to maintenance painting to counter the negative effects on them to some extent. When the economy slows, such demand tends to pick up relative to other house paint sales.

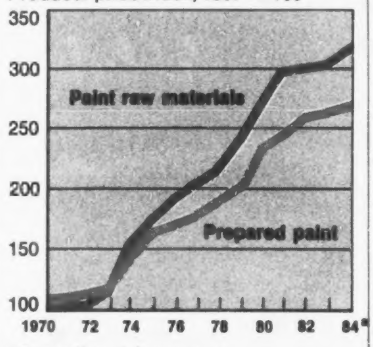
"It is a significant part of our sales," says Dumble. "That kind of usage in the do-it-yourself market will continue as long as housing starts are down and there is not as much resale. People tend to do more in the homes they own. So it compensates to some degree for the dropoff in the other area. I see continued strength in home maintenance painting, simply because in the other area, it continues to be somewhat soft."

Even with this year's good level of volume sales, the most intractable problem for architectural coatings makers is pricing. On the one hand, prices for prepared paint have risen, along with nearly everything else, handily over the past decade. But since 1974, prices of paint raw materials have been rising even faster. Ten years ago, prepared paint cost 1.4 times what it did in 1967; for paint raw materials, the price multiple was 1.5, according to the Department of Labor's producer price index. Now, based on an average of first-half 1984 price indexes, prepared paint costs 2.6 times and paint raw materials 3.2 times what they did in 1967. And this trend is, if anything, accelerating. At midyear the price index for prepared paint had risen just 1.0% from the 1983 average, but the index for paint raw materials had climbed 6.3%.

The result is reduced income for producers of architectural coatings. Lilly Industrial Coatings, for example, in reporting record sales and earnings for its third quarter and nine-month period ending Aug. 31, pointed out that raw material cost increases during the past several months restrained third-quarter profits. "Every paint manufacturer is going through a squeeze right now in being able to recover costs as the raw material prices have gone up," comments Glidden's Dumble.

Raw material prices rising faster than paint prices

Producer price index, 1967 = 100



a January through June average.
Source: Department of Labor

Partly, he says, the squeeze is a function of what he perceives as paint producers' having less leverage with their raw material suppliers than major paint customers have with paint producers. This has led to the manifestation of the current price squeeze most visible to consumers: discounting.

"The percentage of paint sold on sale has been climbing continuously," Dumble says. "You can't pick up the newspaper without seeing a paint sale ad in there. Unless you're going to let other discounters have the market, you are going to have to have the same kind of posture. I don't see other discounters changing their strategy, and that will continue to have an impact on how other marketers address the marketplace. And that's going to mean discounting."

This long-term price imbalance has elevated distribution to a position of prime importance in the strategies of architectural coatings manufacturers. Companies have augmented their own chains of proprietary paint stores and have concentrated on placing their wares in the

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big national home center chains that now command a large share of the do-it-yourself consumer marketplace.

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After architectural coatings, the largest sector of the industry is product coatings-OEM, which accounted for 36% of shipment volume and 35% of sales dollars last year. In 1982, according to Business Trend Analysts, the market was divided in terms of volume among automotive finishes, 16%; metal container finishes, 19%; machinery finishes, 6.4%; sheet, strip, and coil coating finishes, 5.8%; metal furniture finishes, 5.4%; and numerous other end-use segments.

The liveliest segment is the automotive, where PPG Industries, Inmont, Du Pont, and a few other suppliers compete for contracts with car makers in Detroit and abroad. Even though the size of the market has declined sharply since the mid-1970s because of Detroit's well-known woes, the companies supplying automotive finishes have been engaged in an expensive, fast-moving technology race that has been spurred by the auto makers' moves toward compliance with the Environmental Protection Agency's limit on emissions of volatile organic compounds of 3.6 lb per car produced (the deadline for compliance is 1988), energy-conservation needs, and desire for increased corrosion resistance.

In the market for automotive topcoats, car makers have been moving away from low-solids lacquers, which have high volatile organic emissions, to higher-solids enamels. The trend has resulted in an R&D competition to develop high-solids finishes that, while helping bring down emissions levels, also flow well enough to meet assembly-line production requirements. This technical shift has coincided with a general move by car makers to a base coat/clear coat approach to topcoats—a system that permits very high solids content as well as what the automotive industry likes to call "enhanced aesthetics." PPG and Inmont took the early lead in the high-solids technical race; Du Pont, which considers itself the leader in topcoats, continued to supply lacquer products to General Motors, its major customer.

GM's decision to move to enamels as well, however, spurred Du Pont to pick up the pace of its high-solids research. The company, which last year sold its architectural paint business to Clorox in order to concentrate on automotive and other high-performance coatings, now believes it has caught up. After losing four major GM paint contracts in a row to competitors, it has won the last three.

Bruce A. Beardwood, vice president in Du Pont's finishes and fabricated products department, points out that each of the seven recent GM awards were made on increasingly higher solids standards. "If anything, it got tougher, not easier, to be competitive as that scenario developed," he says. "We feel we're fully competitive now on the enamel systems."

Du Pont concedes, on the other hand, that PPG remains the clear leader in the automotive primer segment. That has really been the case since PPG introduced cathodic electrodeposition of primer coats. Now PPG has introduced Uni-Prime, a refined electrocoating sys-

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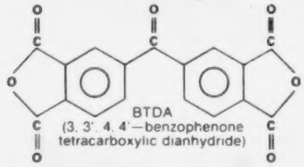

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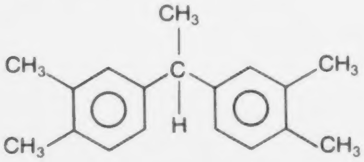

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Worker examines weathering characteristics of test paint panels at Du Pont's Hialeah, Fla., "paint farm" weathering station

tem that the company says eliminates the need for the second, sprayed-on primer coating that most car makers still use. Inmont is also a major player in the primer business, and Du Pont is trying to catch up to PPG via a joint technology development program with Hoechst, which competes in Europe with PPG.

"We're working to develop an alternative technology," Beardwood explains. "Our objective is to become a full-line supplier here in the U.S."

Du Pont, along with others, also has stepped up its research in the automotive aftermarket segment. The technical developments of the OEM market, Beardwood notes, create consequent new product development needs in the aftermarket. Unlike OEM finishes, he points out, aftermarket finishes are air-dried. "So while the finish has to look the same on the car, these are different chemistries," he says. "We've got to respond to what's going on in the OEM."

Automotive refinishing paints, primers, and lacquers accounted for 29% of the special-purpose coatings sector in 1982, according to Business Trend Analysts. The other major segment, high-performance maintenance paints, accounted for 31% of shipment volume, traffic paints 14%, and marine, aerosol, and other specialty coatings the remainder.

In 1983, special-purpose finishes accounted for 14% of total coatings volume and 20% of overall value, according to Census Bureau statistics. Because of their specialty applications, marketers of these products have, in general, managed to raise prices where those in the architectural and, to an extent, OEM sectors have failed. But shipment volume for the sector as a whole has faltered this year.

According to SRI's Connolly, the weak link is probably the maintenance segment, which she says is generally split about equally between coatings to maintain existing chemical, paper, and textile plants and oil refineries and those applied to new facilities. Because new construction of such units is down, this coatings segment has suffered.

Still, specialty coatings are expected to be the fastest growing of the three major coatings sectors, and companies are responding with increased activity. Du Pont, for instance, has been marketing a maintenance coatings and service package for chemical and oil installations. And Mobay Chemical, which produces urethane systems for high-performance coatings formulation, has been vigorously promoting expanded use of its products in coatings for transportation vehicles, industrial facilities, bridges, roofing, and other sectors. Last month, the company announced it was building a plant to produce an improved aliphatic polyisocyanate with high weatherability and chemical resistance properties. □

OCTOBER [illegible]

CHEMICAL & ENGINEERING NEWS

Chemical capacity use continues to improve

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CHEMICAL & ENGINEERING
NEWS

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- **Photovoltaic roof at Georgetown U helps cut energy costs.** Page 5
- **EPA proposes 244 additional hazardous waste sites.** Page 5
- **ICSU plans 10-year study of interactions among Earth's physical, chemical, and biological processes.** Page 6
- **Protests from research organizations quickly lead DOD to overturn its ban on use of cats and dogs in military research.** Page 6

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Defense Department softens attitude on secrecy of research data, allows freer exchange of all but classified information **Page 14**

Congressman's charge that EPA is dragging its feet on proposing sites for Superfund cleanup denied by agency. **Page 16**

Science

Powerful computer programs to analyze data from Fourier-transform NMR experiments developed by chemists at Syracuse. **Page 18**

Laser-based system measures impurities on material surfaces much more accurately than does mass spectrometry. **Page 20**

French chemists make first monomeric nitrilophosphane, isolate first cyclodiphosphazene by dimerizing the monomer. **Page 23**

ACS News

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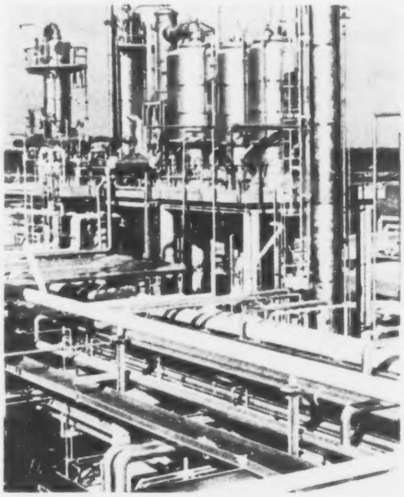
Awards

Research management, organic complexes, innovative teaching, synthesis of polyesters, chromatography, mass spectrometry are specialties of ACS award winners. **Page 30**



Business

U.S. chemical plant capacity use rates, after hitting bottom in first-quarter 1982, have been rising steadily in keeping with the demand in downstream markets. Page 9

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Chemical Plant Capacity Use Continues Steady Rise

Use rate for basic chemicals rose to 78% in third quarter from 72% in first quarter; polymers, however, fell again, slipping to 76% from 81%

William J. Storck, C&EN New York
Bruce F. Greek, C&EN Houston

Ordinarily, the U.S. chemical industry's fortunes and woes pretty much parallel those of the general U.S. economy, but a disturbing drop in some chemical capacity use in the third quarter may challenge that trend.

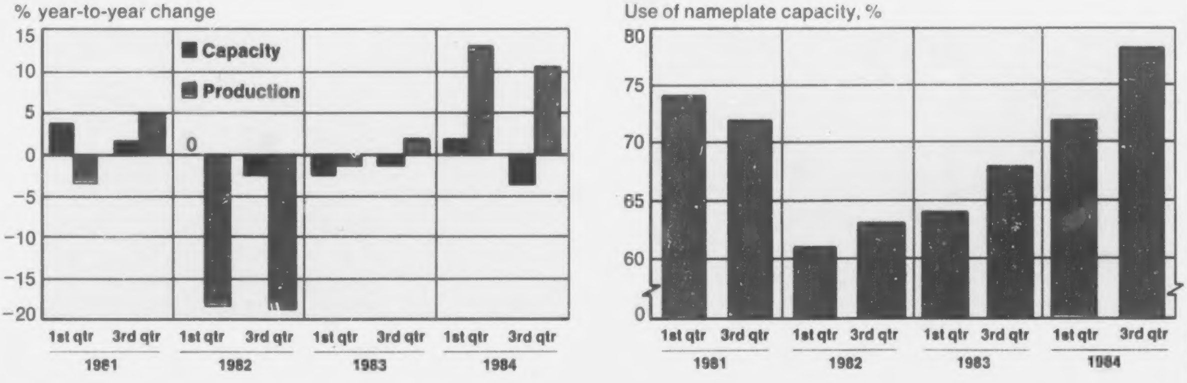
After an up-and-down performance in 1980 and 1981, capacity utilization rates for chemical plants hit bottom in the first quarter of 1982. Since that time, they have been steadily rising as the U.S. general economy fueled demand in downstream markets. The rising trend continued in this year's third quarter for basic chemicals, but, whether because of seasonal factors or because of a real slowdown in markets, capacity use for polymers dropped. According to a twice-yearly survey of major chemical companies by C&EN, capacity use for basic chemicals rose to about 78% in the third quarter from 72% in this year's first quarter and 68% in third-quarter 1983. But for plastics and fibers, capacity use averaged 76%, down from 81% in this year's first quarter and from 82% in third-quarter 1983.

Capacity utilization is a key measure of the industry's health and is used as an indication of the need for new plant and increased capital spending. Although capacity utilization rates have been rising for the industry, however, capital spending has been lagging that for all manufacturing, according to government figures. Industry sources say that this anomaly is because of relatively poor pricing within the industry and that, as prices and the resulting returns rise, there may be more announcements of new plants being built.

Up until now, returns from chemical products have not been high enough to offset the cost of capital needed to build new plants. And, to a certain extent, capacity use rates have not been high enough that new plants are needed. Producers have been able to stretch existing capacity by increasing production efficiencies through modernization and debottlenecking techniques.

However, it's becoming apparent that plant announcements are going to have to come soon, since it typically takes two to three years to build a new chemical plant. Otherwise, some capacity idled during the recession will have to be brought back onstream to avoid shortages in some products in the next couple of years. Starting up idled capacity now seems the preferable choice in some areas, especially when the shut-down plants have been well maintained, simply because of interest rate forecasts and the resulting high cost of financing new plants.

Although the third-quarter decline in capacity use for polymers is



Though basic chemicals capacity has fallen, production has increased . . .

. . . sending capacity use rates upward once again

Sources: Industry and government data, C&EN estimates for 33 leading chemicals

Capacity utilization moved up well for basic chemicals in third-quarter 1984

Billions of lb unless otherwise noted[a]	Third-quarter 1984			First-quarter 1984			Third-quarter 1983		
	Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use	
		Nameplate	Effective		Nameplate	Effective		Nameplate	Effective
Petrochemicals—olefins and aromatics[b]									
Ethylene	36.0	91%	100%	36.5	82%	91%	38.4	74%	82%
Propylene (chemical and polymer)	22.0	77	86	23.0	59	65	23.0	61	68
Butadiene[c]	4.5	58	64	4.5	51	56	4.5	58	64
Benzene (bg)	2.3	64	71	2.4	51	57	2.3	60	67
***p*-Xylene**	5.2	86	100	4.9	85	100	4.9	93	98
Petrochemicals—C_1 derivatives									
Ammonia (mt)[b]	17.5	89	93	17.8	88	91	18.7	64	67
Urea (mt)[b]	7.8	82	92	7.8	83	92	7.8	59	66
Methanol (bg)	1.7	74	83	1.9	60	67	1.8	63	70
Formaldehyde	9.2	61	65	9.2	56	59	9.2	56	59
Chlor-alkalies									
Chlorine (mt)	14.0	72	76	13.4	72	76	14.5	70	74
Caustic soda (mt)	14.9	72	76	14.3	68	72	15.5	66	70
Soda ash (mt)	11.0	74	78	11.0	77	81	10.7	81	85
Acids									
Sulfuric (mt)[b]	58.3	67	70	58.0	66	69	57.5	52	55
Phosphoric (P_2O_5, mt)[b,d]	12.5	87	91	12.5	82	86	12.5	66	69
Industrial gases									
Oxygen **Nitrogen** (total, liquid ttd)	39.4	65	82	39.4	61	75	40.0	64	78
Carbon dioxide (ttd)[e]	19.0	73	81	19.0	67	74	19.6	64	70
Mineral-based organics[b]									
Sulfur (total, mmt)	17.0	55	—	17.0	31	—	16.0	50	—
Potash (mt)	2.2	90	—	2.2	55	—	2.2	50	—
Phosphorus	0.5	93	98	0.6	67	70	0.6	67	71
Plastics intermediates									
Styrene	8.2	95	110	7.8	92	108	8.1	77	91
Vinyl chloride	9.7	69	76	10.0	54	61	9.3	79	87
Toluene diisocyanate	0.7	84	93	0.7	102	113	0.7	83	92
Fiber intermediates									
DMT-PTA[f]	7.6	70	83	7.6	82	97	7.6	80	94
Ethylene oxide	7.0	86	95	7.4	84	93	7.3	75	84
Cyclohexane[b]	3.4	83	89	3.4	62	66	3.4	52	55
Adhesives, coatings intermediates									
Phenol	3.2	74	83	3.3	85	94	3.3	83	92
Vinyl acetate	2.4	99	105	2.4	87	92	2.4	83	88
Pigments									
Carbon black	3.3	87	96	3.3	86	96	3.3	73	81
Titanium dioxide	0.9	97	115	0.9	84	98	0.9	86	100
Solvents									
Acetone	2.8	59	66	2.8	67	75	3.0	67	74
Ethanol (mg)	210.0	88	98	240.0	78	91	240.0	59	62
Methylene chloride	0.8	65	72	0.8	39	77	0.8	71	79
AVERAGE		**78%**	**86%**		**72%**	**82%**		**68%**	**76%**

[a] bg = billions of gallons, mt = millions of tons, ttd = thousands of tons per day, mmt = millions of metric tons, mg = millions of gallons. [b] Substantial capacity currently shut down. [c] Total extraction capacity, which runs 25% more than basic production capacity. [d] Includes both wet-process and furnace-process capacity. [e] Excludes oilfield operations. [f] Dimethyl terephthalate and DMT equivalents of purified terephthalic acid. **Sources:** industry and government sources, C&EN estimates

based on preliminary figures, it is enough to cause some consternation. Polymers and especially fibers have long been considered bellwethers of the chemical industry. If a decline indeed has occurred, and capacity use rates have fallen in both the first and third quarters of this year, then it may mean that chemicals are once again in for some problems.

At least part of the decline probably can be accounted for by capacity increases getting ahead of production increases, especially for plastics, whose production capacity in the third quarter increased 4% from the first quarter of this year. That results in a drop in nameplate capacity use for plastics to 78% in the third quarter from 81% in the

Capacity utilization rates drop again for polymers

	Third-quarter 1984			First-quarter 1984			Third-quarter 1983		
	Capacity	Capacity use		Capacity	Capacity use		Capacity	Capacity use	
Billions of lb per year	(nameplate)	Nameplate	Effective	(nameplate)	Nameplate	Effective	(nameplate)	Nameplate	Effective
PLASTICS									
Polyethylene, low density	10.3	79%	84%	10.1	83%	88%	10.1	81%	86%
Polyvinyl chloride	8.7	61	72	8.3	78	92	8.9	71	83
Polyethylene, high density	7.1	87	92	6.8	87	91	6.3	94	99
Polypropylene	5.4	91	101	5.3	90	100	5.1	86	96
Polystyrene	5.6	69	81	5.1	67	78	5.3	64	75
AVERAGE		**78%**	**86%**		**81%**	**90%**		**79%**	**88%**
SYNTHETIC FIBERS									
Filament yarn									
Polyester	1.5	74	79	1.5	84	90	1.6	88	93
Nylon	1.9	79	85	1.9	85	92	1.9	84	90
Olefin	1.1	62	65	1.1	63	67	1.1	71	75
Staple									
Polyester	2.8	78	83	2.8	82	87	2.7	89	95
Nylon	1.0	74	78	0.99	89	95	0.99	96	102
Acrylic	0.81	80	85	0.83	83	88	0.83	83	88
AVERAGE		**74%**	**79%**		**81%**	**86%**		**85%**	**91%**
OVERALL AVERAGE		**76%**	**83%**		**81%**	**88%**		**82%**	**89%**

Sources: Society of the Plastics Industry, Textile Economics Bureau, industry sources, C&EN estimates

first quarter, and from 79% in last year's third quarter.

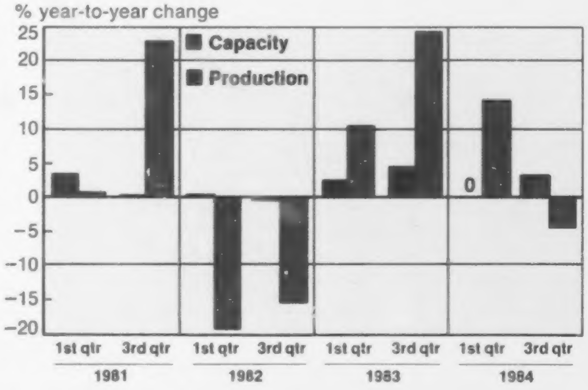
For polyvinyl chloride, capacity for which rose 5% between the first and third quarters, capacity use fell to 61% of nameplate capacity in the third quarter from 78% in the first quarter. But polystyrene, in spite of a 10% rise in capacity between those two quarters, had a rise to 69% of nameplate capacity in the third quarter from 67% in the first quarter.

Synthetic fibers are experiencing a different problem. Imports of foreign textiles are holding down demand for domestic fibers in spite of apparently healthy end-use markets. Capacity use as a percentage of nameplate capacity for synthetic fibers declined to 74% in the third quarter from an average of 81% in the first quarter of this year and 85% in the third quarter of 1983. The fall was led by a 15-percentage-point drop in nylon staple, used mainly for carpets, to 74% from 89% in the first quarter. This was followed by a 10-percentage-point fall for polyester yarn (for apparel use) to 74% from 84%. Much of the imported material is in the form of finished apparel goods.

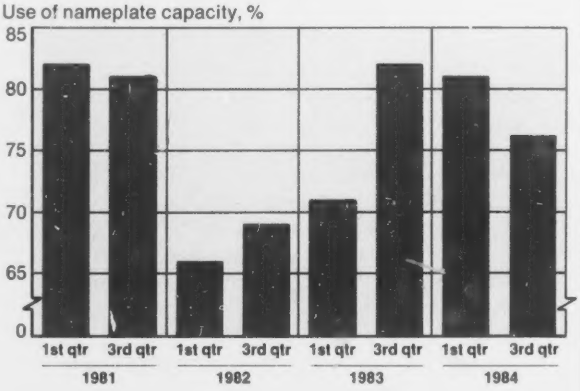
There also is a case to be made that if it were not for inventory building, capacity utilization in the third quarter would have been even lower for both synthetic fibers and for plastics. Stocks at producing plants increased for both of these product categories.

In contrast to the downstream polymers, however, capacity utilization for basic chemicals rose in the third quarter, with the average utilization rate as a percentage of nameplate capacity for 33 basic chemical products reaching 78%. As a percentage of effective capacity, the av-

Polymer capacity has increased, but output has fallen . . .



. . . driving capacity use rates down from a year earlier



Sources: Society of the Plastics Industry, Textile Economics Bureau, industry sources, C&EN estimates

C&EN capacity use indicator: the ground rules

Capacity use at chemical plants is difficult to measure and requires certain assumptions. These bring some order to the maze of variables affecting this critical indicator of the industry's health.

With the help of industry and government sources, C&EN measures capacity use as a percentage of both nameplate and effective maximums. Nameplate capacity is the official design capacity of plants. Effective capacity is the practical maximum after reductions for unplanned maintenance, corrosion problems, changes in product mix, and other influences. Although engineering companies and industry statistics groups try to make nameplate capacity data as real as possible, practical problems almost always reduce effective maximums to 85 to 95% of the official totals. For short periods, plants can run at more than 100% of effective top capacity, but such a rate doesn't last more than a few months.

Capacity use is given over as much of a calendar quarter as production data permit, with no seasonal adjustment. The figures are for plants actually operable. At present, some products such as ethylene, ethanol, chlorine, polystyrene, ammonia, and urea have plants temporarily shut down because of weak markets. These plants still are included in capacity totals. The totals exclude new plants just starting up and old plants out of operation for long periods because of accidents. As much as possible, capacity figures stay current with expansions.

Capacity data don't take into account other temporary fluctuations for fuel and electric power interruptions, equipment failure, and feedstock scarcity or substitution. The feedstock variables, for example, have been important in the past few years in ethylene production, altering maximum output for several coproducts such as propylene, butadiene, and benzene.

Products in C&EN's capacity use survey are the same as those in the Key Chemicals and Key Polymers series. These are the core products of the industry, the building blocks leading to downstream production of thousands of more specialized products.

erage use rate increased to 86% in the third quarter from 76% in the first quarter and 70% in last year's third quarter. Effective capacity, normally 85% to 95% that of nameplate capacity, is the rate that plants can run over long periods of time. Capacity use as a percentage of effective capacity can run more than 100%, but usually for only short periods.

In the third quarter, the average utilization rate for both the 20 organics and the 13 inorganics among those basic chemicals surveyed was 78% of nameplate capacity. For the organics, that percentage is up from 74% in the first quarter and from 68% in the third quarter last year. For the inorganics, it is up from 68% in the first three months of this year and from 66% a year before.

Led by the upsurge in the housing market, the highest capacity utilization rate for any product category in the third quarter was for pigments, where carbon black and titanium dioxide had an average capacity use of 92% of nameplate capacity. That's up from 85% in the first quarter and 80% in the third quarter last year.

The strong construction market also carried over to adhesives and coatings intermediates, where capacity use for phenol and vinyl acetate averaged 87% in the third quarter, up a bit from an equally strong 86% in the first quarter and from 83% in third-quarter 1983.

The apparent problems in synthetic fibers and in plastics did not hurt the intermediates for these two product categories. Average capacity use for plastics intermediates—styrene, vinyl chloride, and toluene diisocyanate—was a good 83%, the same as it was in the first quarter and up from 80% in the third quarter last year. Capacity use for fiber intermediates—dimethyl terephthalate and purified terephthalic acid, ethylene oxide, and cyclohexane—averaged 80% in the third quarter, up from 76% in the first quarter and from just 69% in 1983's third quarter.

The largest recovery among the basic chemicals surveyed came for the mineral-based inorganics—sulfur, potash, and phosphorus—for which capacity use averaged 79% in the third quarter, a large increase from the 51% in the first quarter and 56% in the third quarter a year ago.

The government's ending of its payment-in-kind crop set-aside program, though not helping much from the previous quarter, has boosted considerably capacity use from a year ago for many chemicals in the survey. For instance, capacity use for the major acids—sulfuric and phosphoric—averaged 77% of nameplate in the third quarter, up slightly from 74% in the first quarter. However, this is a substantial increase from the 59% capacity use in the third quarter of 1983—an extremely poor fertilizer year.

Capacity use of the two main organic fertilizers—ammonia and urea—also got a boost. Their average capacity use in the third quarter was 86%, the same as in the first quarter. However, in third-quarter 1983, capacity utilization for these two products averaged only 67%.

The survey also shows a healthy increase in capacity use for olefins and aromatics. Utilization rates for these chemicals, which have a large effect on industry fortunes, increased to 75% of nameplate capacity in the third quarter from just 66% in the first quarter this year and 69% in third-quarter 1983. Capacity use for these chemicals was helped by small shutdowns in ethylene, propylene, and benzene. There was a 6% increase in *p*-xylene capacity between the first and third quarters, but apparently all this was utilized, since capacity use was 86% in the third quarter and 85% in the first quarter. The shutdowns in ethylene, propylene, and benzene plus increased production caused capacity use in each of these products to increase, and in the case of ethylene to exceed 90% of nameplate. □

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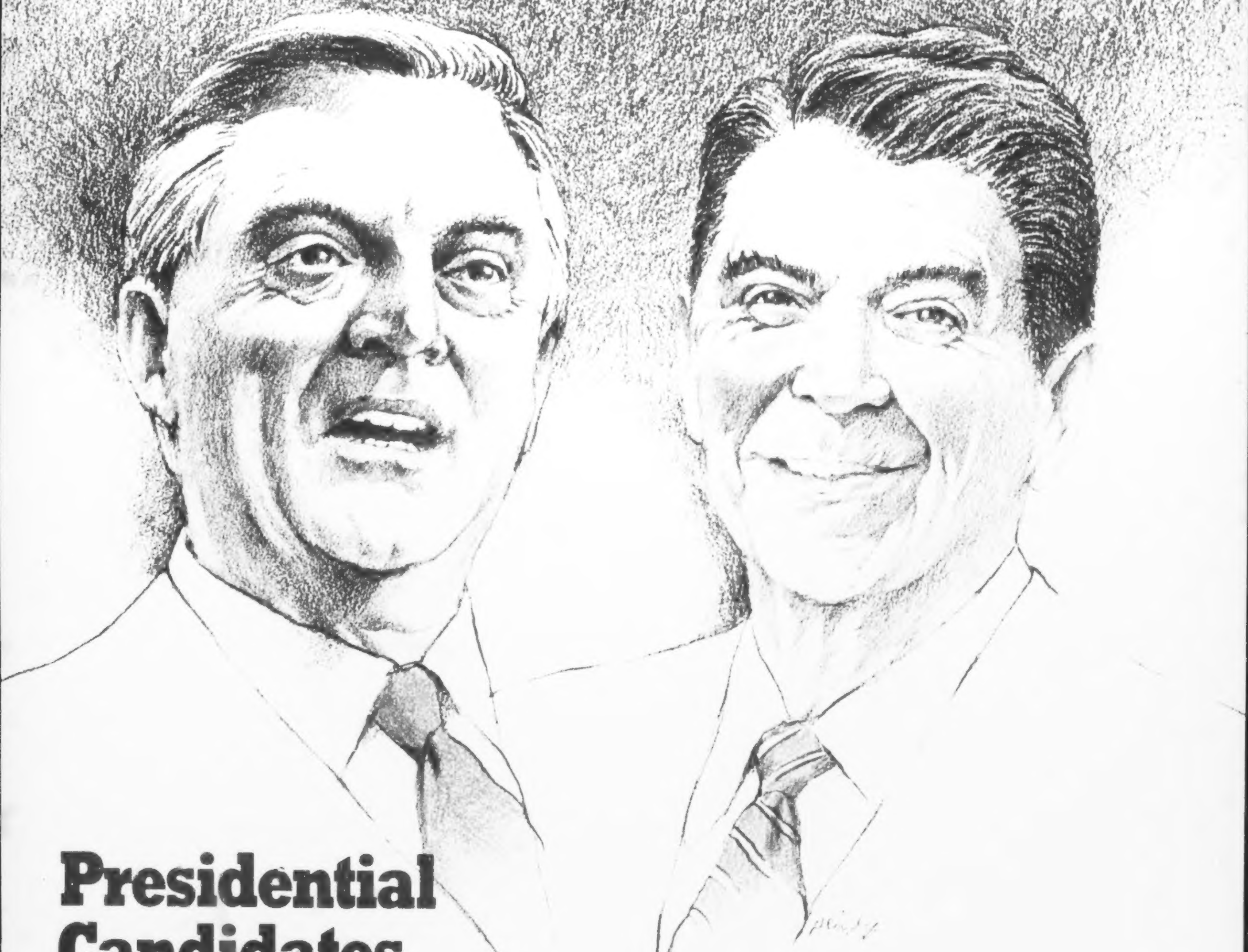
NEWS



Presidential Candidates

Their views on science and technology
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News of the Week

- **Use of genetically engineered organisms as pesticides, even in small-scale field tests, must be cleared by EPA.** **Page 4**
- **Study of Alzheimer's disease gets boost with $3.5 million in grants to university research centers.** **Page 5**
- **Permanent science programing development unit established for public television.** **Page 5**
- **New Jersey residents get a whiff of malathion as storage tank blows cover, sending up a cloud of the vaporized insecticide.** **Page 5**

Business

An omnibus trade bill has emerged from House-Senate conference committee, appears certain to be approved. **Page 12**

Vinyl siding is headed for strong growth and will become most widely used siding material by end of decade. **Page 13**

Government

Environmental mediation conference focuses on changes that have evolved over the past 10 years in settling disputes. **Page 15**

Science

Synthesis of stereochemically formidable antibiotics achieved for Ph.D. thesis highlights new synthetic methods. **Page 17**

Technology

Chemical mechanisms of wood digestion are yielding to research on chemistry of anthraquinone pulping. **Page 20**

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"The Salaried Professional: How to Make the Most of Your Career" by Joseph Raelin gives general guidance in career planning. **Page 24**

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ACS awardees have made gains in environmental science, gas phase chemistry, three-phase emulsions, organic and inorganic anions, structure and reactivity, and catalytic reactions. **Page 28**

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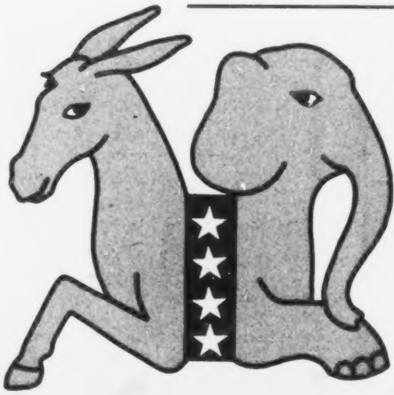

News Focus

Ronald Reagan and Walter Mondale give their views on science policy goals, science education, basic research, and technological innovation. **Page 6**

feit goods. This, too, is much less drastic than a last-minute proposal made in the House by Rep. Richard A. Gephardt (D.-Mo.). He wanted to graduate those three countries completely out of the preference system program, but his proposal was voted down in the House.

Included in the new trade bill is authority for the President to negotiate a free-trade arrangement with Israel. Chemical imports from Israel now are small, but the few companies that are affected by them consider them to be sensitive items. Some observers also fear that producers in other countries may ship their products through Israel to get free-trade benefits.

The bill is not as specific about negotiating a free-trade arrangement with Canada, but it does encourage it. Such an arrangement with Canada would be of more concern to the chemical industry because a sectoral free-trade deal covering petrochemicals already has been suggested and discussed (C&EN, June 25, page 19).

Chemical industry trade experts no doubt will welcome the provision of the new trade bill that gives the President authority to negotiate reductions in trade barriers affecting investments, services trade, and performance requirements. These subjects will be high on the U.S. priority list of topics when and if another round of multilateral trade talks get under way.

Missing, however, from the omnibus trade legislation approved by the conference committee are the tough provisions of H.R. 4784, the Trade Remedies Reform Act. This bill—the so-called Gibbons bill after Rep. Sam Gibbons (D.-Fla.) who introduced it—would have drastically expanded the scope of U.S. antidumping and countervailing duty laws. The original bill would have offered remedies against so-called downstream dumping, upstream subsidies, and natural resource subsidies.

The chemical industry was split in its attitude toward the Gibbons bill. Many multinational companies, fearing it could hurt their own foreign operations, opposed it. Others, particularly ammonia producers hurt by imports from Mexico, applauded it.

Earl Anderson, New York

Vinyl siding poised for major growth

Vinyl siding, a large market for polyvinyl chloride, is poised for a spurt of good growth and easily will become the most popular siding material by the end of the decade, according to Predicasts, a Cleveland, Ohio-based supplier of business information and market research.

According to a Predicasts market survey on single-ply and other roofing and siding markets, residential construction in 1983 consumed about 550 million sq ft, which ended up trailing brick use of 890 million sq ft, hardboard use of 720 million sq ft, aluminum use of 700 million sq ft, and plywood use of 650 million sq ft.

That lineup is expected to change dramatically through the mid-1990s, when vinyl siding will account for 1.3 billion sq ft, or more than 30% of all siding consumption. In 1983, vinyl made up just 14% of siding demand. Predicasts says that percentage will rise to about 23% in 1988.

To garner that share of the siding market, according to Predicasts, vinyl siding consumption will grow about 13% per year between 1983 and 1988. Growth will slow after that to an average of less than 4% per year. Meanwhile, total siding consumption will be growing at less than 2% per year between 1983 and 1988. Then demand actually will decline between 1988 and 1995, according to Predicasts, to the point that in 1988 consumption will be about 3% less than it had been seven years earlier.

Also, while vinyl siding consumption is enjoying healthy growth, many of its competitors will be victims of falling demand. Between 1983 and 1988, aluminum siding consumption likely will fall 3.4% per year, brick use 3.1% per year, steel use 1.9% per year, and hardboard and plywood use will remain essentially unchanged.

By 1995, the decline in these products will become more severe, according to the Predicasts survey, and only vinyl siding and miscellaneous materials will show any growth. Predicasts says the "other" category will show growth because of the introduction of composite materials such as waferboard and concrete.

Between 1983 and 1995, the roofing and siding market will be supported by modest levels of new housing construction, although less than those levels experienced during previous periods of rapid growth, and by continuing replacement and addition requirements.

The $1500, 109-page study also delves into the fragmentation of the market, in which no single firm holds a share of more than 7%. However, concentration does vary widely among segments, from highly fragmented in bricks to highly concentrated in hardboard production. In addition, the industry is shaped, according to the study, by the presence of large, diversified, and usually vertically integrated firms. □

Vinyl will have largest share of siding market by 1988

	Consumption			% average annual change		
Millions of sq ft	1983	1988	1992	1983–85	1988–95	1983–95
Aluminum	700	590	510	−3%	−2%	−3%
Steel	110	100	90	−2	−2	−2
Vinyl	550	1020	1300	13	4	7
Brick	890	760	570	−3	−4	−4
Hardboard	720	730	700	0	−1	0
Plywood	650	660	570	0	−2	−1
Lumber & other shingles	100	70	40	−7	−8	−7
Other	300	450	470	8	1	4
TOTAL SIDING	4020	4380	4250	2%	0%	1%

Source: Predicasts

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OCTOBER 22, 1984

CHEMICAL & ENGINEERING

NEWS

1985 Employment Outlook

For undergraduates, the core chemistr
courses are not enough Page 29

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OCTOBER 22, 1984

News of the Week

- **Nobel Prize in Chemistry goes to R. Bruce Merrifield, U.S. protein biochemist; physics prize shared by Carlo Rubbia, Simon Van der Meer.** **Page 6**
- **Panel of atmospheric chemists calls for U.S. to take the lead in understanding chemistry of the troposphere.** **Page 7**
- **American Cyanamid sells titanium dioxide business to NL Industries and its Formica Brand Products business to newly formed company.** **Page 8**
- **National Science Board gets three new members, all with technology and business backgrounds.** **Page 8**

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Business

Chemical industry's high rate of earnings growth is beginning to show signs of slowing. **Page 11**

Government

House committee's planned two-year study of science policy will be huge, may explore politicization of science. **Page 16**

Science

Nonvolatile, proteinaceous pheromone discovered that elicits copulatory behavior in golden hamsters. **Page 21**

New service identifies most-cited lab instrument makers and where lab instruments are used. **Page 23**

Awards

Atmospheric chemistry, high-tech materials, designed synthesis of aromatic compounds, separations technology, macromonomer chemistry, and mass spectrometry on Mars—all are in the limelight from the work of the 1985 ACS awardees. **Page 58**

Employment Outlook

Improved demand for chemists and chemical engineers brightens the outlook for students interested in pursuing careers in these fields. **Page 29**

1985 Employment Outlook

Career Opportunities for Chemical Professionals

The upturn in the nation's economy has resulted in a noticeable improvement in demand for chemists and chemical engineers. At many colleges and universities, employers were considerably more active in recruiting graduating chemical professionals last spring than they had been a year earlier. Employers also had more jobs to offer than they did in 1983. The result is that fewer graduates this year found themselves without jobs to look forward to when they received their diplomas.

After two consecutive years of decline, the median annual starting salary of B.S. chemists increased this year. As it has for some years, the median annual starting salary of Ph.D. chemists likewise increased in 1984. Rises also were noted in the median starting salaries of B.S., M.S., and Ph.D. chemical engineers.

The volume of "positions open" advertising in C&EN this year is strikingly higher than the year before. At the ACS national meeting in Philadelphia this past August, too, the mood of employers and job applicants was described as decidedly upbeat compared to a year earlier.

Undergraduate Studies

Professional chemists recommend several study areas that undergraduates might pursue. High on the list are biochemistry, polymer chemistry, writing, and computer science. **Page 30**

Demand

The pessimism that characterized the job market in 1983 has given way to a much brighter outlook this year as employers hire more chemists and chemical engineers. **Page 40**

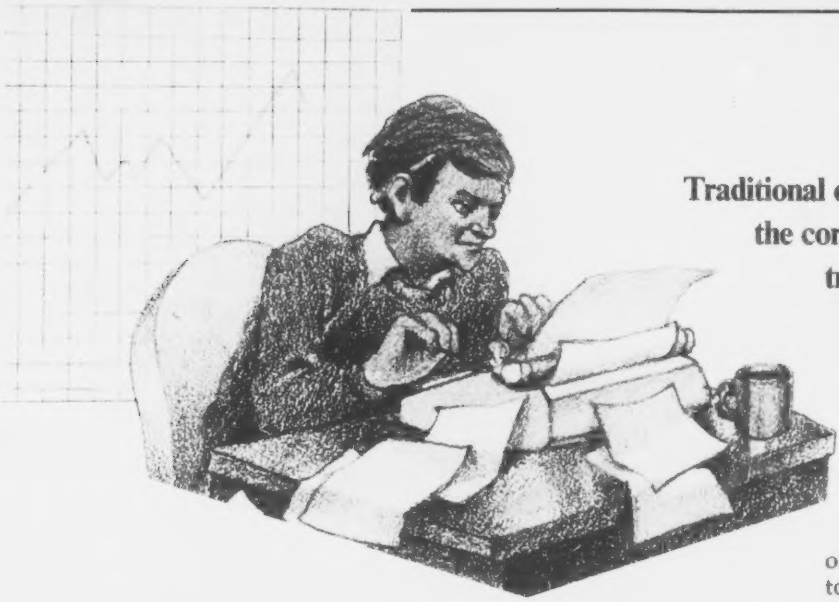
Salaries

Salaries of experienced B.S., M.S., and Ph.D. chemists increased between March 1983 and March 1984, but not as much as in the previous 12 months. Salaries of new B.S. and Ph.D. chemists also rose. **Page 51**

Career Planning

The American Chemical Society and other organizations can supply a wide range of information to people looking for advice about careers in chemistry and chemical engineering. **Page 55**

Traditional chemistry may be the core to their undergraduate training, but B.S. chemists need to know much more



Undergraduate Studies

The key subdisciplines of chemistry are the essential foundation for any undergraduate aspiring to become a chemist. But chemists also must know more, much more, to succeed. Undergraduate training, therefore, must encompass a wide variety of both scientific and nonscientific subjects.

Among the sciences, for example, biochemistry and polymer chemistry have strong adherents; computer science and advanced mathematics are widely considered essential. Many industrial chemists, moreover, advocate training in industrial chemistry or chemical engineering—along with some work in business and management. Also, nearly everyone thinks that training in writing and public speaking is important for fledgling chemists.

Insights into the importance—or lack thereof—of various areas of undergraduate study show up in a survey carried out earlier this year by the American Chemical Society. The survey was conducted to determine how ACS members evaluate various areas of study, both in chemistry and other fields. Its results have been amplified with interviews C&EN has had recently with several experienced chemists.

As would be expected, the four core courses in chemistry—organic chemistry, analytical chemistry, physical chemistry, and inorganic chemistry—are cited most frequently as very important. These are courses that all students are required to take to get a B.S. degree in chemistry.

Of the four, organic chemistry gets the highest rating; 88% of the respondents consider it very important. On the other hand, physical chemistry is considered very important by only 74% and inorganic chemistry by only 73% of the respondents. In general, too, the core courses are rated somewhat higher by academic chemists than by those working in industry. Virtually no one, however, thinks any of them unimportant.

Despite widespread agreement that all undergraduates in chemistry should study these core subjects, some disagreement has developed regarding how much work should be required in each. The greatest controversy has centered on inorganic chemistry.

Twenty or 30 years ago, almost all chemistry majors took the equivalent of two semesters of inorganic chemistry. In fact, ACS-approved programs leading to a B.S. in chemistry required this.

In the late 1960s and early 1970s, many chemistry departments reduced the required amount of inorganic chemistry to one semester. One reason was that many students already had learned a good bit of inorganic chemistry in high school. The amount of study devoted to inorganic chemistry also was lessened to make room for increased work in physical chemistry and other chemical areas. In addition, many professors looked upon inorganic chemistry as a relatively inactive and unexciting field that needed less attention.

Reflecting this thinking, the ACS Committee on Professional Training in 1977 issued a new set of guidelines for ACS-approved curricula that, among other things, reduced the amount of required work in inorganic chemistry to one semester.

However, this change has met increasing opposition, especially from inorganic chemists, who think that inorganic chemistry is not being given enough emphasis. They point out that high schools now are teaching less inorganic chemistry than in the past. Furthermore, the subject is becoming a more active area of chemistry, particularly with the rapid development of semiconducting materials, organometallic compounds, and high-tech ceramics. As a result, the ACS committee issued new guidelines a year ago that require ACS-approved programs for B.S. chemists to contain the equivalent of approximately two full semesters of inorganic chemistry.

Some people argue, too, that students should take advanced elective courses in these core subjects of chemistry. For example, Jerry K. Larson, manager of employment at Pfizer's central research division in Groton, Conn., recommends that undergraduates who are specifically interested in a career in organic chemistry take one or two advanced courses in this area. "When we are

Four core courses in chemistry rate highly in ACS survey

	In current undergraduate curricula, this area is		
	Very important	Somewhat important	Not very important
CHEMISTRY			
Organic chemistry	88%	11%	1%
Analytical chemistry	82	16	2
Physical chemistry	74	22	4
Inorganic chemistry	73	24	3
Biochemistry	41	48	11
Polymer chemistry	31	52	17
Health and safety chemistry	31	51	18
Industrial chemistry	31	50	19
Chemical engineering	28	51	21
Surface chemistry and catalysis	22	57	21
Toxicology	17	52	31
Geochemistry	5	38	57

	In current undergraduate curricula, this area is		
	Very important	Somewhat important	Not very important
OTHER AREAS			
Writing and public speaking	73	25	2
Computer science	70	28	2
Calculus, linear algebra, and statistics	62	34	4
Information retrieval for chemists	55	39	6
Physics	44	45	11
Biology and other life sciences	33	54	13
Business and management	25	53	22
Foreign languages	19	49	32
Humanities	14	50	36
Social sciences	11	51	38

Source: American Chemical Society

Chemists have found writing useful in their own careers

	How useful was your undergraduate work in this area?			
	Very useful	Somewhat useful	Little use	Did no work
CHEMISTRY				
Organic chemistry	73%	22%	4%	1%
Analytical chemistry	69	23	6	2
Physical chemistry	54	31	12	3
Inorganic chemistry	54	33	10	3
Biochemistry	23	21	16	40
Polymer chemistry	13	13	12	62
Chemical engineering	14	11	7	68
Industrial chemistry	11	14	9	66
Health and safety chemistry	7	14	9	70
Surface chemistry and catalysis	9	15	14	62
Toxicology	5	9	9	77
Geochemistry	2	6	10	82

	How useful was your undergraduate work in this area?			
	Very useful	Somewhat useful	Little use	Did no work
OTHER AREAS				
Writing and public speaking	52	28	7	13
Calculus, linear algebra, and statistics	45	41	13	1
Information retrieval for chemists	32	29	11	28
Physics	30	41	25	4
Computer science	26	19	8	47
Biology and other life sciences	23	29	17	31
Foreign languages	16	37	36	11
Humanities	12	37	37	14
Business and management	11	18	13	58
Social sciences	8	33	37	22

Source: American Chemical Society

interviewing B.S. graduates to work in a synthetic organic chemistry lab," he says, "we generally are looking for people who have taken more than the required core course in organic. We prefer people who have done a senior research project in synthetic organic chemistry. People with such backgrounds become productive scientists in our laboratories much sooner."

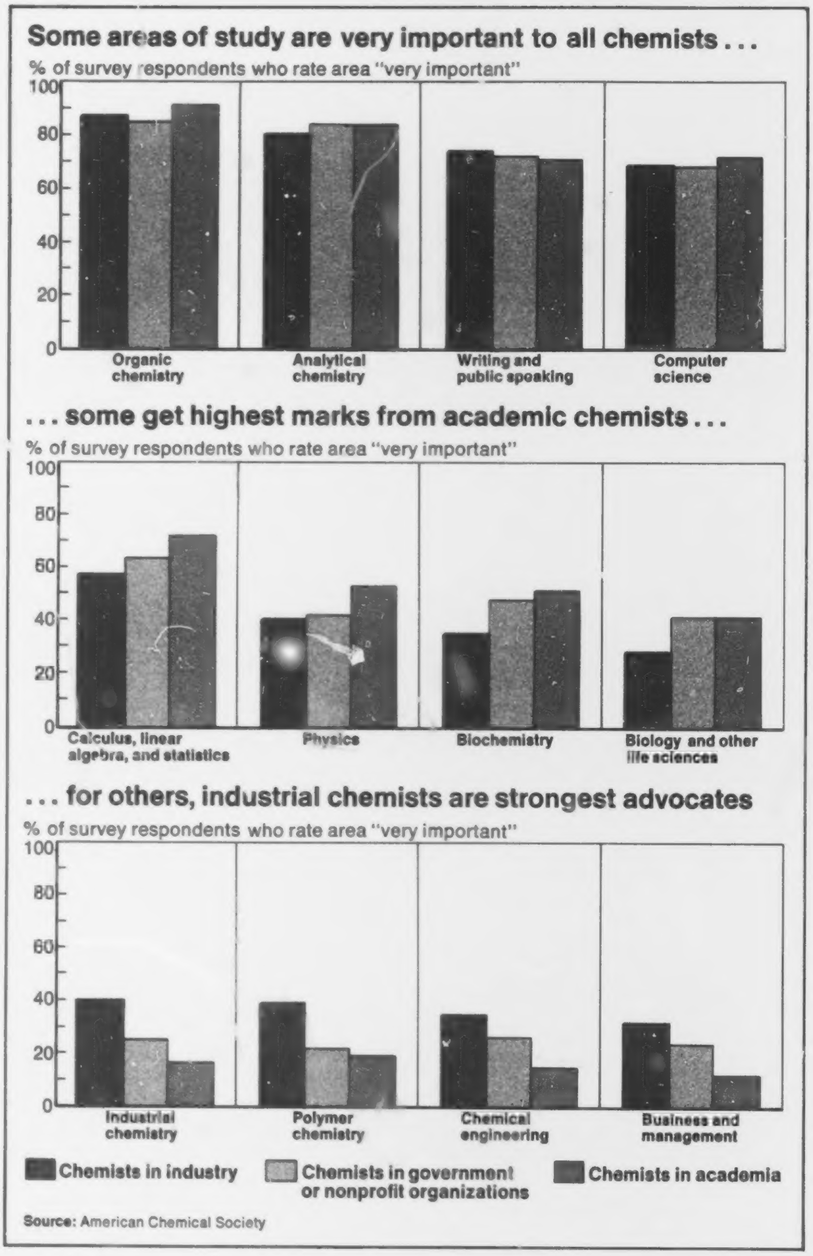
Larson, as well as other scientists, recommends that students do a senior research project if it is offered. The experience, they agree, greatly enhances B.S. chemists' laboratory training and improves the chances that they will get the job of their choice.

Biochemistry, although generally not required of undergraduates, also is highly rated; 41% of the ACS survey respondents think it is very important. Again, though, academic chemists rank it as a bit more important than chemists working in industry. And 38% of the respondents who had undergraduate training in biochemistry regard it as very useful and 35% as somewhat useful.

In fact, an increasing number of scientists—especially biochemists—urge that biochemistry be made at least a one-semester required course in the undergraduate curriculum. They believe that the amount of biochemistry that might be learned as part of a course in organic chemistry or biology is usually insufficient. C. David Gutsche, chemistry professor at Washington University in St. Louis, says, "In their heart of hearts, many biochemists, I believe, would like to see biochemistry as a core course in the undergraduate chemistry program."

Many faculty members point out that the undergraduate curriculum is only four years in length and that enlarging it to more than four years might impose a severe financial burden on many students who already are strapped with rising college costs. Moreover, the existing four-year curriculum is crammed with required elective courses, so if something is added, something must be eliminated. And few professors want anything dropped—particularly in their specialized fields.

Observers point out that biochemistry is becoming an increasingly important area because of the large-scale activity going on in such fields as molecular biology, biotechnology, pharmaceutical chemistry, and nutrition. A chemist who does not have a reasonably good understanding of these areas could be at a



Some areas of study are very important to all chemists . . .

. . . some get highest marks from academic chemists . . .

. . . for others, industrial chemists are strongest advocates

Source: American Chemical Society

serious disadvantage professionally.

Karen W. Morse, head of the department of chemistry and biochemistry at Utah State University, says, "I am not one of those people who recommend that biochemistry be made a mandatory course for all B.S. chemists. However, I do believe that if students can fit a separate course in biochemistry into their schedules, it would be highly desirable for them to do so."

Larson of Pfizer notes that a one-semester course in biochemistry—however useful—is only an introduction to the subject and certainly does not make a person a biochemist. "When we are looking for B.S. people to work in biochemistry," he comments, "we prefer to hire those who have a B.S. in biochemistry, rather than a person with a B.S. in chemistry who has taken, let's say, only two courses in the subject."

One of the more frequent complaints made by industry recruiters is that most graduating chemists do not know enough about polymer chemistry. This field usually is covered in a course in organic chemistry and possibly in courses in general and physical chemistry. But many in industry believe that undergraduates also should take an elective course in polymer science.

This year's ACS survey found that 31% of the respondents view polymer chemistry as very important in the undergraduate curriculum. Of the 38% of the respondents who actually have had undergraduate work in polymers, 34% think that it was very useful to them and an equal number think it was somewhat useful. Industrial chemists, in particular, hold polymer training in high regard; 39% think it very important for undergraduates compared with only 19% among academic chemists.

Health and safety chemistry also is rated by 31% of the survey respondents as very important for undergraduate training. Perhaps reflecting the growing emphasis on health and safety matters in recent years, 48% of the respondents who received their B.S. degree during the 1980s rate this area highly, but less than 30% of those who graduated before 1979 do so.

Most chemists agree, to be sure, that every course in chemistry should stress the importance of avoiding health and safety hazards. They urge that alertness to hazards must be ingrained in chemistry students from the outset of their undergraduate education. But many also believe that most students get enough training in safety during their regular courses. Others, however, recommend that students take a one-semester course devoted solely to safety and health. Some schools offer such a course, but many do not.

Two other areas that many chemists consider important in the undergraduate curriculum are industrial chemistry and chemical engineering. This is especially the case with chemists employed by industrial firms. Industrial chemistry is viewed as very important by 40% of the industrial respondents but by only 16% of those at universities and colleges. Similarly, 35% of industrial chemists but just 15% of academic chemists rate chemical engineering very important.

Several years ago, some people were urging undergraduate chemistry majors to take three or more electives in chemical engineering. They reasoned that chemical engineers then had little difficulty in finding jobs with high salaries, but chemists were struggling to get jobs, even at appreciably lower salaries. The argument was that some training in chemical engineering made a chemist more marketable.

This argument lost much of its appeal as a glut of new chemical engineers developed last year, many of whom had more difficulty than chemists in finding jobs. This situation is likely to change in the next three or four years, however, as a decrease in the number of freshmen enrolled in chemical engineering results, in turn, in a declining number of graduates.

Some academic chemists, moreover, rebel at the idea of chemistry majors taking several electives in chemical engineering. Such training, they contend, deprives students of chemistry courses that should be part of their undergraduate studies. In addition, many professors are not comfortable with the notion of turning out graduates who are a hybrid of chemist and chemical engineer.

Undergraduates need to know more than just chemistry, to be sure. For example, advanced mathematics (calculus, linear algebra, and statistics) is rated as very important by 62% of the respondents to the ACS survey, although academic chemists consider it much more important than do chemists with industrial jobs. Some faculty members urge, for example, that chemistry majors take a separate course in statistics, noting that the attention given to the subject as part of conventional courses in analytical or physical chemistry often is inadequate.

Physics also is viewed as very important by 44% of the respondents, again with academic chemists giving it appreciably higher marks than it receives from industrial chemists. Actually, both calculus and physics are required parts of the undergraduate chemistry curriculum because both are prerequisites to the study of physical chemistry.

Rated even higher today, however, is training in computer science; 70% of the people covered by the ACS survey considered it very important, and it gets equally high marks from chemists who work in industry, the universities, government, and nonprofit organizations. Although some training in computers may be provided in such courses as analytical or organic chemistry, many experienced chemists think that undergraduates should take at least one or two electives in the use of computers.

One recent development has been a sharp rise in the number of freshmen who have become familiar with computers in high school. It is not unusual to find freshmen bringing personal computers to campus along with their hi-fi equipment and sports gear. Although this is not likely to eliminate the need for universities to teach computer science, it is likely to reduce the time needed to cover the basic information.

Edging out computer science in importance, however, is training in writing and public speaking. The ACS survey finds that 73% of chemists highly recommend these areas for undergraduates. Moreover, 60% of those who did undergraduate work in writing and public speaking consider them to have been very useful in their own careers; only 8% found them of little use.

Many employers say that the greatest deficiency of many new B.S. chemistry graduates is their failure to communicate effectively. Chemists need to write skillfully, they add, to convey ideas properly to coworkers, professional peers, supervisors, and even top management. Public speaking is similarly important.

Henry A. Bent, professor of chemistry at North Carolina State University, notes, "If you want to sell your ideas to other people, you need to express yourself skillfully." Adds Gutsche of Washington University, "I am appalled by the failure of many B.S. chemistry students to write literate English."

Many people argue that these are skills that actually should be acquired in high school. But what most students learn about writing and speaking in high school is inadequate.

One obvious place where college students might learn to write and speak competently is in the English courses that usually are required of freshmen. Many chemistry professors argue, however, that freshman English courses generally stress

Survey evaluates chemistry curriculum

Late last winter, as part of its annual survey of the salary and employment status of its members, the American Chemical Society also surveyed a large group of its members to determine what they think of the relative importance of various areas of study in the current curriculum leading to a bachelor's degree in chemistry. At the same time, respondents were asked to evaluate the usefulness of these study areas in their own chemical careers.

The original idea to conduct this survey was proposed last year by Gerhard G. Meisels, professor of chemistry and dean of the college of arts and sciences at the University of Nebraska, Lincoln, who at that time was chairman of the ACS Committee on Economic Status. Henry A. Bent, professor of chemistry at North Carolina State University, who is chairman of the ACS Committee on Professional Training, also supported the proposal.

Meisels and his committee believed that the education survey would help determine the preferred areas of study for B.S. chemists, so that chemistry graduates would be of greatest value to their employers. In turn, the committee thought, better education would lead to an improved economic status for chemists.

Bent believed the survey would be worthwhile because it would assist his committee in drawing up future ACS guidelines for the professional training of B.S. chemists. These guidelines, in turn, would be useful to departments of chemistry in formulating their educational programs and to chemistry professors in recommending courses of study to students.

Results of the survey are based on responses from about 10,600 ACS members, as compiled by the Statistical Services Office of the ACS Department of Professional Services.

creative writing, with a strong emphasis on fiction that encourages colorful, vague, and even florid writing. The emphasis often is on expressing feelings, rather than on stating facts, which is not the type of writing wanted in scientific reports meant to convey information and conclusions concisely and clearly.

Some chemistry professors declare that students can be taught to write proficiently in their chemistry courses. Examinations in all of these courses, they believe, should contain at least some short essay questions that are graded not merely for their factual content and scientific accuracy but for grammar and style. Chemistry professors and instructors should then point out to students where their writing is deficient.

Unfortunately, the majority of examinations in chemistry consist of multiple-choice questions or require the student merely to fill in blanks. Professors also are too busy with other responsibilities to edit the responses to essay questions and to improve students' writing quality.

In some science courses, however, students are called upon to write reports. Professors might well use these reports as a means of pointing out to students how their writing can be improved.

Some schools, recognizing that conventional English courses often do not place sufficient emphasis on the type of writing required of scientists, offer specialized courses in technical writing. Many people urge students to take such a course, or an elective in public speaking, to improve their effectiveness in communication.

Almost everyone agrees that B.S. chemistry students should be familiar with the methods available for obtaining scientific information from books, journals, and reports. This type of training is considered very important by 55% of the respondents to the ACS survey.

A widely held view, however, is that knowledge of chemical information retrieval, although quite valuable, usually can be learned satisfactorily as an adjunct to conventional chemistry courses. In the beginning stages of a senior research project, for example, students would be obliged to search the literature, which would give them useful experience in information retrieval.

Several years ago, many universities required B.S. chemistry students to study a foreign language, usually German because a substantial part of the chemical literature was published in German. But in recent years, this language requirement often has been dropped.

The ACS survey supports this decision. Only 18% of the respondents consider foreign languages a very important area of study and among recent graduates the percentage drops to 13%.

One reason is that many German scientists now publish their findings in English. Other German research papers are now available in English translations. The journal *Angewandte Chemie*, for example, has been available in both German and English for a number of years. And the next supplement of the Beilstein Handbook of Organic Chemistry (a series of books that will cover the literature from 1960 to 1979) will be published in English rather than in German.

Fifteen or 20 years ago, some chemists were also very interested in learning Russian because of the growing volume of chemical knowledge emanating from the Soviet Union. More recently, however, this interest has waned partly because many Russian scientific journals are now also published in English. In fact, many scientists believe that English is gradually becoming the universal language of science.

Some observers add that students would be much better advised to take one or more courses in computer science, rather than in a foreign language. They consider computer literacy a lot more important to chemists these days.

General agreement exists that universities are not trade schools and that university students should receive a reasonably well-rounded education. The function of four years of college leading to a B.S. degree in chemistry is not solely to teach a student about the sciences.

Gutsche says, "I definitely feel it would be unwise to curtail the nonscience undergraduate curriculum to make room for more science courses." Harry S. Hertz, director of the National Bureau of Standards' center for analytical chemistry, comments, "Courses in the humanities enrich a person's life. Besides, you definitely have to know more than chemistry when you interact with people in the great wide world."

Most professors emphasize that a chemistry education should give the student an opportunity to delve into many different fields of knowledge, such as humanities and fine arts, or social and behavioral sciences. These areas of study rank even lower than foreign languages in the ACS survey, though. A mere 14% of the respondents consider humanities and fine arts very important, and 10% rank social sciences as very important. On the other hand, 36% believe humanities and 38% believe social sciences are not very important. Among more recent graduates—those getting their B.S. since 1970—only about 10% view humanities as very important.

Some people, in industry particularly, recommend a course in business or economics, which, they believe, will give students working in industry a greater appreciation of the business world. For example, 25% of survey respondents think that training in business and management is very important. (Among academic chemists just 12% think such studies of much importance.) Dale B. Fox, technical employment manager at Monsanto, declares, "I believe a course in economics can be quite desirable for industrial chemists. Such a course can heighten a student's awareness that a chemical process can be a technical success but a business disaster because of economic conditions, such as the rising price of raw materials."

Another observer says, "You don't want to graduate B.S. chemists who can talk to other people only about chemistry, physics, and math. You want them to have a greater breadth of knowledge. You want them, if possible, to know about music, philosophy, anthropology, and psychology. You want to stimulate their interest in new areas of learning. In other words, you want them to develop an adequate appreciation of what constitutes world civilization—an appreciation that they will continue to expand in later years as they pursue further study and reading." □